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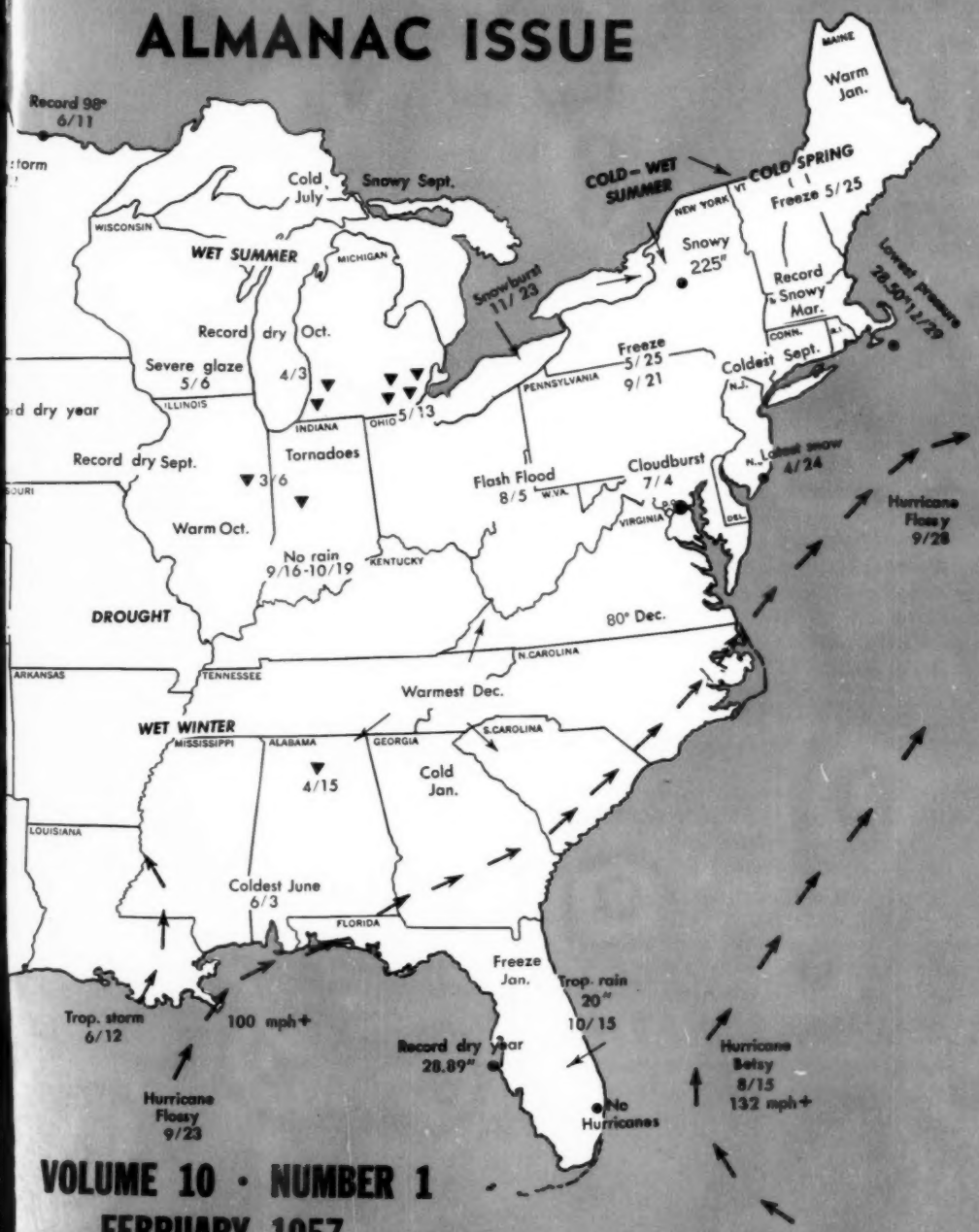

VOLUME 10 · NUMBER 1
FEBRUARY 1957

"SOME PEOPLE ARE WEATHERWISE BUT MOST ARE OTHERWISE"—BENJAMIN FRANKLIN

WEATHERWISE

THE MAGAZINE ABOUT WEATHER

DAVID M. LUDLUM, *Editor* HENRY W. BULKLEY, *Associate Editor*

AMS Elections and Awards

At the 37th annual business meeting of the American Meteorological Society on 30 January in New York City, new officers and members of the Council were announced from the mail ballot of AMS members. Dr. Thomas F. Malone of Hartford, Connecticut, has been elected to serve as Secretary for the year 1957, and Henry DeC. Ward of Boston, Massachusetts, has been re-elected to continue as Treasurer for the current year.

The new members of the Council to serve through 1959 are:

Dr. John C. Bellamy, Cook Research Laboratories, Chicago

Gordon D. Cartwright, U. S. Weather Bureau, Washington

Dr. Richard A. Craig, Air Force Research Center, Boston

Dr. George P. Cressman, Air Weather Service, Washington

Dr. Robert G. Fleagle, University of Washington, Seattle

At annual dinner of the 150th National Meeting three awards were made. The Award for Outstanding Services to the Society was presented to Professor Carl-Gustaf Rossby of Stockholm, Sweden, for "his great vision and tireless efforts in transforming the AMS into an international scientific and professional organization." Dr. Vincent Schaefer of Schenectady, New York, received the Award for Outstanding Contribution to the Advance of Applied Meteorology for his pioneering work in artificial nucleation. The Award for Outstanding Services by a corporation was made to The Travelers Insurance Companies for "developing an entirely new field of specialized weather service for the American public."

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Progress During 1956 in American Meteorology

ROBERT D. FLETCHER, *President, American Meteorology Society*

THE year 1956 in United States meteorology was marked by an encouraging increase in the capabilities of weather-measuring equipment and by a greater confidence in the acceptance of objective-forecasting procedures, especially those employing large electronic computers. At the same time there was a growing realization among professional meteorologists that steps must be taken to uphold their standards and through these to protect their customers and the profession itself.

The American Meteorological Society has been active in the year's developments, particularly those related to consolidating and strengthening the position of our professionals, both private and governmental. It is not possible in this report either to list all of the noteworthy developments which took place in our field during the past year or to describe in detail those which are mentioned. However, what is presented in the following paragraphs may serve as highlights which, in turn, can foreshadow the course of events in our science and profession for the next several years.

EQUIPMENT

Research continued in the development of improved equipment for sensing meteorological elements. Of most immediate promise for the measurement of humidity aloft, where the lack of data has always plagued forecasters, has been the development work on the carbon-strip sensing element for radiosondes and dropsondes and the infra-red hygrometer for aircraft. For temperature sensing, the vortex thermometer was successfully employed on aircraft in increasing numbers, and research was conducted to adapt such instruments to sensing from high-performance aircraft.

As a result of findings at Arcata, California, the Navy established five atmospheric-conductivity stations for operational tests of forecasting procedures utilizing correlations between atmospheric-conductivity and fog-dissipation data. The rotating-beam ceilometer and the transmissometer had increased use at a number of airports. Research was stepped up on the utilization of these and other equipment items for rapid measurement of "slant-range visibility." Anticipating the introduction of jet aircraft into United States commercial aviation, the airline and associated industries have followed these developments closely and with strong interest.

The average rawinsonde height reached by our weather services increased nearly 10,000 feet. This improvement resulted from the development of better balloons and from use of better operational procedures with the GMD-1A tracking equipment. At the same time, added emphasis was placed on the development of still better equipment to measure strong winds aloft despite low elevation angles and to reach great heights despite low temperature conditions.

Radar equipment similar to the AN/CPS-9, developed by the military exclusively for weather-detection use, was secured and put

into operation also by the Weather Bureau. This equipment, reaching out 250 miles and occasionally farther, has made it possible for forecasters to make short-period predictions of precipitation and severe weather with greatly increased accuracy. With the network of radar stations sufficiently dense, research meteorologists undertook the important problem of investigating radar as a synoptic tool by constructing "radar mosaics" over large areas of the Mississippi Valley. Meteorologists began to realize that a perhaps radically different approach to the analysis and prognosis problem might have to be developed for really effective use of this new type of tool, in which certain kinds of weather elements are observed over sizeable areas rather than merely at discreet points.

In the field of aircraft weather reconnaissance, the Air Weather Service replaced its WB-29's with WB-50's—aircraft capable of greater performance with ranges of 3,200 nautical miles and pressure altitudes of 30,000 feet. The greatest single improvement in the history of aerial weather reconnaissance was the installation of WB 50's automatic-navigation equipment operating on the Doppler-radar principle. With such instrumentation it became possible to secure, under nearly all operating conditions, excellent and continuous observations of winds at flight altitudes, as well as very accurate position fixes over remote ocean areas.

The year 1956 witnessed the start of an operational automatic-weather-station network by the Weather Bureau after successful tests at three semi-isolated locations. The network now consists of seven stations where surface temperature, humidity, altimeter setting, wind, and visual range automatically are measured and placed on the teletype circuits for operational use. Meantime, the Navy conducted research to perfect a boat automatic weather station, as well as to develop other varieties of remote stations automatically observing and transmitting current weather data.

The Weather Bureau increased the number of ships reporting in its moving-ship program. Three Military Sea Transport Service ships operating in the Pacific were added to the two which constituted the program prior to 1956. Two merchant ships and one oceanographic ship were added in the Atlantic and the same duplicated in the Gulf of Mexico. The ships, which report radiosonde in addition to sea level data, are of great value in filling in the frequently vast blank areas on our weather maps.

A program called "Weathervision" was introduced by the Air Weather Service at one of its larger bases during 1956. The program consists of a centrally located forecasting office which sends out by television, on request, weather information to satellite locations. At the existing site there are ten satellite receivers on which are displayed maps and charts as requested. A two-way audio circuit links the customer and forecaster.

It became increasingly evident that communications of weather information required careful scrutiny and the development of higher-performance equipment. As a partial answer, the Weather Bureau began to introduce continuous-roll facsimile equipment into some of its field stations. At the same time, the Air Force increased the speed of transmission of weather information over several of its circuits from sixty to one hundred words per minute. Recognizing that our present system is becoming outmoded in the light of new developments, the American Meteorological Society established an ad hoc committee of experts to review investigations now in progress and to consider communications requirements of the present and near future.

Special Research and Data-Gathering Projects

The Meteorology Panel of the U. S. National Committee for the International Geophysical Year devoted much time and effort to formulating an effective program for the meteorological discipline. Probably the most glamorous phase of the program is the series of efforts under way in the Antarctic. Here, under the leadership of the Weather Bureau and with Navy logistic support, weather-observing stations are being established at the Pole and at six other sites on the continent. A complete weather analysis and forecasting central is being set up to provide weather service for aircraft and other operations in Antarctica.

The Panel designated a selected network of Weather Bureau, Air Weather Service, and

Navy stations at which high-altitude-reaching rawinsondes will gather data during the IGY sufficient for preparation of charts for research use up to a height of 100,000 feet.

In cooperation with Canada and several South American governments, the USNC for the IGY established a line of stations reaching from pole to pole along approximately the meridian of 80° West. Here, during the 10-day "Meteorological Intervals" representing the four seasons, concerted efforts will be made to reach very high altitudes and otherwise to secure frequent and closely spaced observations at the surface and aloft. Special high-altitude equipment developed by the Signal Corps will be utilized at a number of stations along the meridian; the high-performance balloons, carrying hypsometers to measure pressures, have provided reliable soundings to as high as 131,000 feet, and the average height of the test flights was 101,000 feet.

The National Hurricane Research Project, conducted by the Weather Bureau, experienced its first "hurricane season" during 1956. The season was characterized by a sparsity of these disastrous cyclones in the Florida area, the center of activity of the project. Nevertheless, flights were made into several cyclones by Air Force planes specially instrumented by the Weather Bureau. These, together with new Caribbean upper-air stations established by the project, augmented the first set of on-the-spot hurricane data for use by the project scientists.

During the year the National Academy of Sciences appointed a Meteorological Committee, composed of scientists of various physical disciplines, to explore new approaches in the field of meteorology, one of which is the investigation of new methods of observing atmospheric processes.

During 1956 the President's Advisory Committee on Weather Control issued a statement regarding its evaluation of present capabilities to augment precipitation artificially. Having a subpoena power it was not forced to exercise, and with the complete cooperation of commercial cloud-seeding organizations, the committee studied available data on cloud seeding and concluded that significant correlations (suggesting increases of around 15%) were evident in the mountainous area along the Pacific Coast during winter and spring. Evaluation of data for other areas was not completed. The committee felt that the results of the West Coast evaluation could not be extended at the time to any other area, regardless of terrain, nor could they be applied anywhere to any other season of the year.

Weather Forecasting

The Severe Local Storm Center of the Weather Bureau and the Severe Weather Warning Center of the Air Weather Service occupied the same set of offices in Kansas City and successfully experienced their first tornado season under this *modus operandi*. At the same time, research aircraft flights were made into areas of suspected tornado activity to obtain meteorological data for use in increasing the capability of the profession to detect and predict tornado occurrences. Meanwhile, use of sferics (alone, or in combination with radar) to aid in tornado detection was also tested with results that suggest useful relationships. Research on the tornado phenomenon was stepped up at several universities and within governmental agencies.

As far as forecasting is concerned, without much doubt, the activity of most significance was that of the Joint Numerical Weather Prediction Unit, which successfully completed its first full year of operation. Very encouraging is the report that at least two major weather forecasting centrals have replaced their own locally produced 500-mb prognoses with the products of the JNWP Unit. The centrals apply minor subjective refinements to the prognoses, and devote the time accordingly saved to interpreting the prognoses in terms of weather and winds. The JNWP Unit, in its process of testing various atmospheric models, adopted the so-called "thermotropic model" with improved results and incorporated a special ageostrophic assumption into the barotropic model it also employs. Late in the year, the unit's function of preparing objective map analyses with the IBM-701 computer was augmented by installation of automatic data-processing equipment with which data are fed from the standard weather teletypes directly to the computer without being "touched by human hands"; the new equipment also checks the data for errors and discards poor reports. The coverage of the unit's maps was increased to include most of the Northern Hemisphere. This year the

Robert G. Miller, Travelers Weather Research Center, and William J. Supple, Data Processing Section, at the IBM 650, which is used to prepare 24-hour prognostic charts and to compute the probability of precipitation.

unit also began to disseminate maps of "vertical velocities" which provide estimates of upward and downward speeds of the air averaged over rather large areas in the lower half of the atmosphere. Research to relate the patterns on such maps with the distribution of clouds and precipitation commenced.

At the Joint Weather Records Library of the Navy, Air Weather Service, and Weather Bureau in Asheville, North Carolina, the year was marked by the installation of the Air Force's IBM 705. This piece of electronic equipment is characterized by a very high capacity for receiving and turning out data, a capability greatly needed in climatological activities which deal with historical data in vast numbers.

The ability of electronic computers to process data with great rapidity and in large quantity has been harnessed in other areas. For instance, a private weather service in New England has developed and is successfully using a statistical method of predicting the weather 24 hours in advance through employment of an IBM 704 computer, and goes so far as also to state quantitatively the probability that such weather will be experienced. Work has also begun, with this and other computers, to develop statistical regression equations with which forecasters can predict hurricane tracks and certain important terminal-weather elements at selected airports. Although in some cases the resulting forecasts may be no better than those that are now available, the peculiar capability of the computers to calculate "probabilities of occurrence" is expected by the researchers to result in a final product of greatly increased value. Tests have also begun on use of the computer to turn out information as to the "best" tracks (as far as winds are concerned) which should be taken by aircraft on long-distance flights.

In view of requirements for forecasting for high-altitude flight operations, several forecast centers replaced the 500-mb with the 300-mb map as their basic weather chart. Intensified probings of the upper atmosphere with improved rawinsondes and specially instrumented aircraft have helped to provide the forecasters with ammunition in their attacks on the difficult high-altitude forecast problems. As a result of these data-gathering efforts, a "jet-stream model" was presented to the profession near the end of the year.

In the face of insufficient trained manpower conditions in many forecasting stations, several airline and governmental forecasting centers have taken the lead in systematizing their routines through use of objective forecasting techniques and through objective

use of prognostic charts prepared at large weather centrals. Operational use of JNWP products has already been mentioned. Other stations have begun also to employ a routine which uses maps received via facsimile from the National Weather Analysis Center and other centrals as the basic framework. Utilization of locally prepared, statistical techniques for predicting local weather conditions has become an important element in the systems adopted at many stations. Although the pioneering in this area of systemization of procedures preceded the year 1956, the year just ended has seen a never-before-experienced impetus in this direction.

Non-Governmental Professional Activities

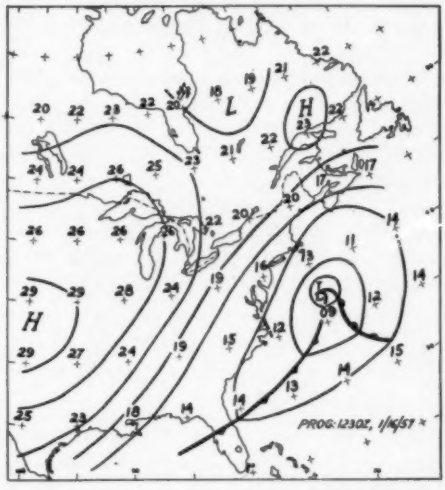
The year 1956 witnessed a concerted attack on poor practices in weather telecasts. One of our local branches conducted an evening meeting featured by a panel discussion among professional meteorologists and active weather telecasters from several large cities. Another branch was host to a National AMS Meeting devoted entirely to the subject. This was a joint meeting with the National Association of Radio and Television Broadcasters and was attended by many key figures in the telecasting field. The AMS Committee on Radio and Television was very active during the year. It submitted to the Council a well-conceived plan whereby, in essence, a Seal of Approval would be awarded to a Professional Member of the Society for display on his radio or television weather program provided the latter meets the standards established by the Society. The Council has approved nearly all the recommendations of the committee, and it is probable that the program will be completed and placed in being in the near future.

Our corps of private consulting meteorologists continued their functions during 1956, preparing weather forecasts and other varieties of meteorological advice for their private clients and, in some cases, conducting research under contract with governmental agencies. The work of most of these consultants was an outstanding credit to our profession. At the same time it was recognized by a number of serious-minded private and governmental professional meteorologists that such work, if not conducted under a body of uniformly high standards, could be deleterious and even disastrous to clients as well as undermining to our profession. These considerations led our Committee on Industrial Meteorology to investigate ways and means whereby the Society could take appropriate protective measures. The committee submitted a draft report to the Council on requirements and procedures for issuance of a Certificate of Competency for Consulting Meteorologists. The Council has approved the report in principle. The sense of the report is that the Society is to issue the certificate to such applicant consulting meteorologists who, operating under the AMS Code of Ethics and Standards, have met certain requirements of experience and training.

Activities of the Society

The number of local branches of the Society increased from 36 to 41 in 1956; they include one in Germany and one in Puerto

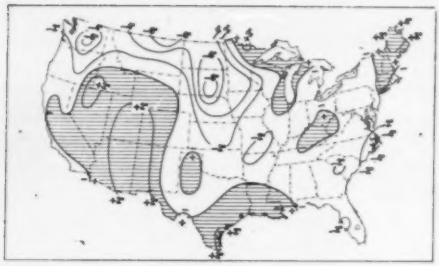
(*Continued on page 28*)

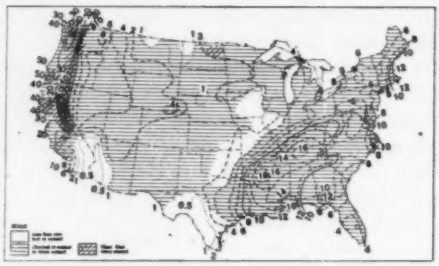


Prognostic sea level chart for 1230 GMT, 16 January 1957, prepared on the IBM 650 computer. The synoptic-climatological method is used to compute grid-point pressure values from the circulation patterns at 1230 GMT on 14 and 15 January. The computer also provides a precipitation index which gives the probability of precipitation from midnight to midnight on the day for which the prognostic chart is prepared. For the case above, the index was 10.61 which meant that the chances of precipitation were 97 out of 100 and, if the precipitation occurred, the most probable amount was 0.19 inches. Actually 0.20 of an inch were recorded at Hartford on 16 January.

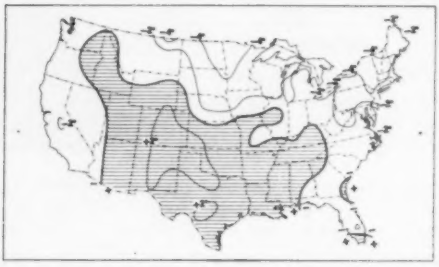
THE WEATHER BY SEASONS 1956

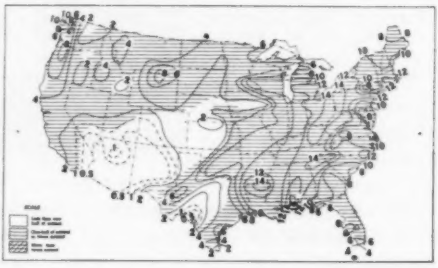
WINTER (DECEMBER–FEBRUARY) 1955–1956



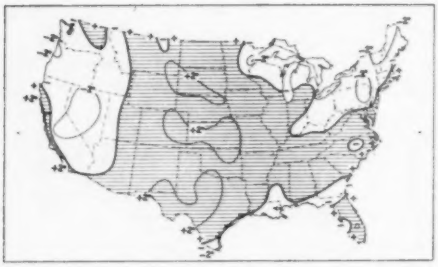


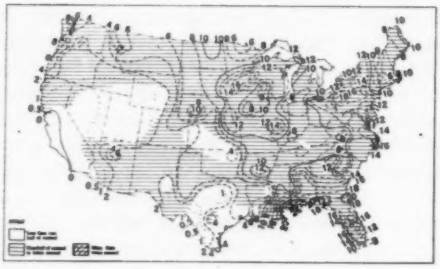
SPRING (MARCH–MAY) 1956



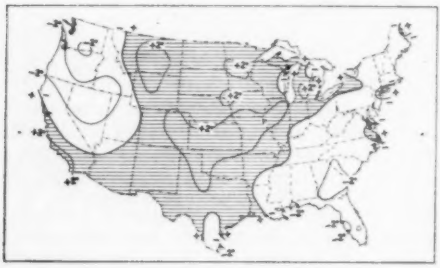


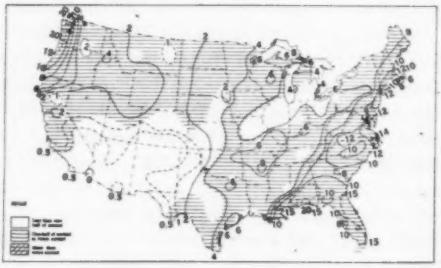
SUMMER (JUNE–AUGUST) 1956





FALL (SEPTEMBER–NOVEMBER) 1956





Charts show the departure of the temperature from normal in degrees Fahrenheit by seasons 1956. USWB charts.

Charts show the total precipitation in inches by seasons 1956. USWB charts.

The Circulation and Weather of 1956*

WILLIAM H. KLEIN, *Extended Forecast Section,*
U. S. Weather Bureau, Washington, D. C.

WINTER

THE outstanding characteristic of the general circulation during the 1955–56 winter season was the unusual behavior of the zonal index. Five-day mean values of this index, which expresses the average strength of the prevailing westerlies between latitudes 35° and 55° N in the Western Hemisphere, are plotted in figure 1 for both 700 mb (above) and sea level (below). After undergoing an unprecedented double cycle in October 1955, the index failed to rise above normal during any 5-day period from 28 October 1955 to 22 February 1956, the longest period of continuous low index ever observed. However, normal values were reached briefly, at 700 mb for the period ending 25 December and at sea level for the period ending 5 February. These two dates mark the beginning and end of a pronounced index cycle which culminated in the lowest 5-day mean indices on record, for 7–11 January at 700 mb and 11–15 January at sea level. Thus there was a marked deficit of westerly wind speed at middle latitudes for four months of the cold season.

* This paper is based on the series of articles on the weather and circulation of each month appearing regularly in the *Monthly Weather Review*.

The regional circulation features accompanying this low index state are well illustrated in figure 2, the mean 700 mb chart for January 1956. This map closely resembles the corresponding chart for the preceding month, December 1955. Both months were characterized by deep troughs off the east coast of the United States, in the eastern Pacific, and near Midway; and by strong ridges of the blocking variety over the Bering Sea and the area from Hudson Bay to Greenland. The latter were accompanied by the largest anomalies of 700 mb height observed in the Northern Hemisphere, + 680 ft in Labrador and + 600 ft in the Aleutians. The blocking nature of these positive anomalies was accentuated by the presence of pronounced negative anomalies and strong west winds (jet streams) to the south of each center.

The extreme and persistent nature of this year's December–January circulation pattern was reflected in the weather in many parts of the country. Southward displacement of the jet stream and accompanying cyclonic activity, together with stronger than normal southwesterly flow of moist Pacific air, produced heavy precipitation nearly everywhere west of the Continental Divide. More than

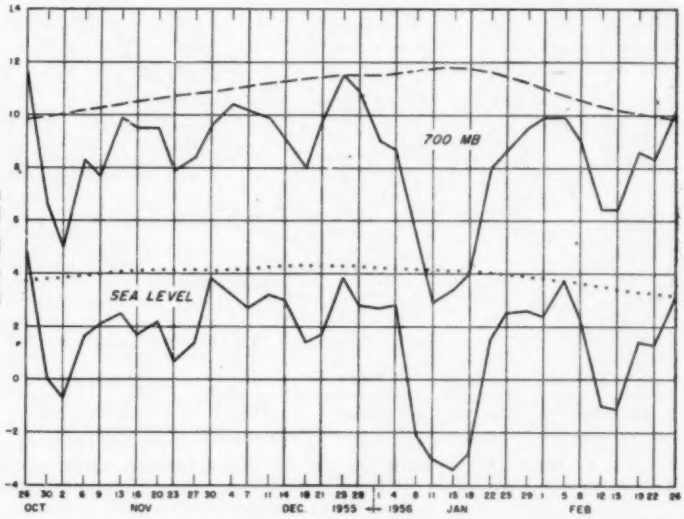


FIG. 1. Time variation of zonal index in meters per second for the Western Hemisphere in the latitude belt 35°–55°N. Solid lines connect 5-day mean values (plotted on last day of period) for 700 mb. (above) and sea level (below). Variation of normal index is shown by dashed line for 700 mb. and dotted line for sea level.

twice the normal amount fell in the West Coast States (see chart of total winter precipitation on page 8), and disastrous floods resulted. At Sacramento, California, total precipitation of 19.78 inches during December and January was the greatest consecutive 2-month total since 1862.

The North Atlantic States were also under the influence of moist air masses from the adjacent ocean during much of the winter, as indicated by strong anomalous flow components from the east in figure 2. Onshore, cyclonic flow was most extreme from 7 to 17 January, when the zonal index was at its all-time low (fig. 1). During this period an intense quasi-stationary cyclone off Hatteras dominated the weather of the eastern United States, producing gales, high tides, snow, sleet, glaze, rain, and floods in the Northeast and damaging frost in the Southeast. In the central portion of the country cold dry weather prevailed as a result of northwesterly winds at 700 mb between a ridge over the Rockies and a trough off the East Coast. St. Louis, Missouri, reported 46 consecutive days without measurable precipitation, from 2 December 1955 to 17 January 1956, by far the longest such period of record.

The December–January regime was abruptly reversed in February, as the deep troughs off the east and west coasts filled rapidly at middle and low latitudes, thus lengthening the wave length and resulting in formation of a new trough from the Missouri Valley southwestward through Lower California. Warm, moist air carried by southwesterly flow ahead of this trough produced heavy precipitation and above-normal temperatures in the eastern half of the country. To the rear of the trough, in the West, mild wet weather was replaced by cold dry conditions. However, the outstanding weather item of the month was the persistent and severe cold observed over the entire European continent. This cold wave was produced by strong east winds south of pronounced blocking highs in the northern portions of the Atlantic and Eurasia. It was thus another manifestation of this winter's hemispheric low index circulation.

Spring

The low index, blocking type of circulation again predominated during April 1956. As a result the axis of strongest westerlies (or jet stream) at 700 mb was depressed as far as the southern border of the United States, as shown by the lower dotted line in figure 3. Numerous cyclones traversed the country just north of this jet and produced generally heavy precipitation east of the Mississippi, with major snowstorms in the Mid-West and Northeast, tornadoes in the Southeast, and duststorms in the southern Plains.

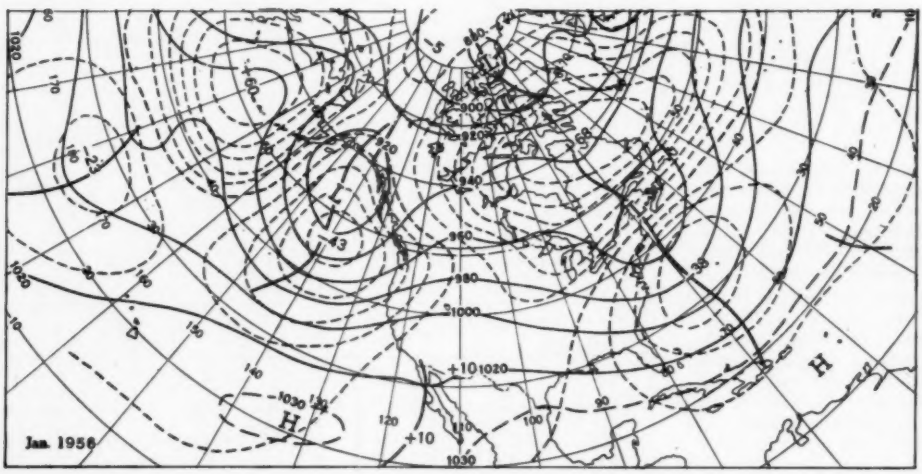


Fig. 2. Mean 700 mb. height contours with departures from normal superimposed (both in tens of feet) for January 1956. Outstanding features are large centers of positive anomaly in Labrador and Aleutians, surrounded by negative anomalies.

Blocking action was largely responsible for widespread cold weather during April. It operated in two rather typical ways to keep temperatures below normal. At first, when 700 mb heights were above normal in eastern Canada, widespread cyclonic activity to the south kept 700 mb heights and surface temperatures below normal in the eastern United States. Later, when blocking was centered farther west and the upper-level ridge over western Canada and Alaska was consequently stronger than normal, cold air was advected into the states east of the Rocky Mountains. The trajectory of the migratory anticyclones producing these outbreaks of polar continental air is well illustrated by the upper dotted curve in figure 3, representing the northern branch of the mean 700 mb jet stream for April.

The other months of the spring season, on the contrary, were dominated by fast westerly flow of the high index type. During both March and May the axis of the principal westerly jet stream was farther north than in April. This northward shift was particularly marked in May (dashed line in fig. 3), when it was accompanied by strong ridge development in the central and southern United States. In this area pronounced anticyclonic vorticity south of the jet was responsible for early season heat and drought. This was the warmest and driest May on record at several cities in Texas and Kansas and the eighth consecutive month with below normal precipitation at Des Moines, Iowa.

The pattern of average surface temperature departure from normal was very similar during both March and May and is well indicated by figure 4, the anomaly of mean temperature in the lowest 10,000 ft of the atmosphere. A particularly noteworthy feature of this figure is the large area of below normal values in Canada, Alaska, and the Arctic Ocean. This cold pool combined with persistent stronger than normal northwesterly flow at 700 mb to produce one of the coldest and snowiest spring seasons on rec-

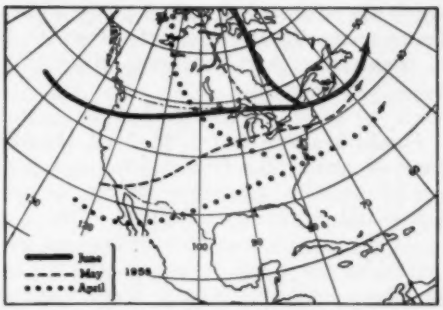


FIG. 3. Location of axes of jet streams on 700 mb. mean charts for April (dotted), May (dashed), and June (solid). Note the pronounced northward and eastward progression from month to month.

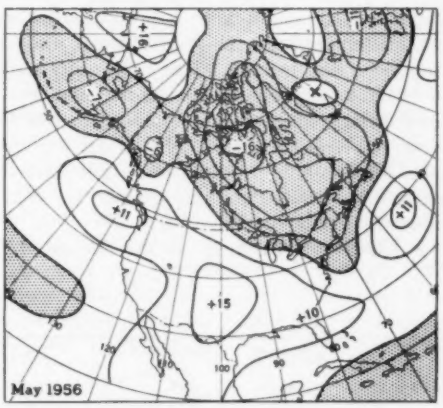


FIG. 4. Anomaly of mean thickness (in tens of feet) in the layer from 1000 to 700 mb. for May 1956, with colder than normal values stippled. As in March and April, the polar source region over central Canada was unusually cold.

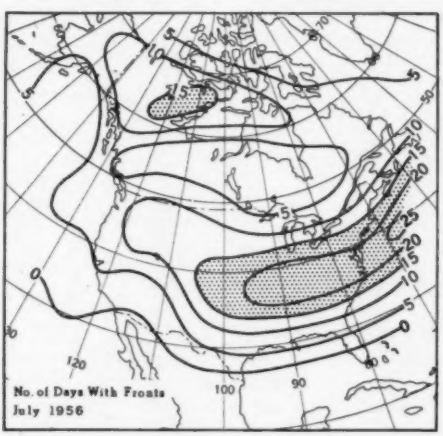


FIG. 5. Number of days in July 1956 with surface fronts of any type within unit squares (with sides approximately 500 miles). Frontal positions taken from Daily Weather Map, 1330 EST. The unusually high frequency of fronts was responsible for cool rainy weather in much of the country.

ord in the northeastern quarter of the United States (note departures of more than 4° F in temperature chart for spring on page 8).

Summer

Figure 3 shows that from April through June the axis of the 700 mb jet stream progressed steadily northward in the United States and eastward in Canada. The area of above normal surface temperatures expanded in the same directions, so that by June even the North Atlantic States warmed to above normal, while the maximum departures for the month were located in the northern rather than the southern Plains as before. The principal westerly belt was now so far north that easterly wave and tropical storm activity were able to produce below normal temperatures in the Southeast due to cloudiness and rainfall. The only other part of the country with below normal temperatures during June was the Pacific Northwest. Here the poleward shift of the jet stream from May to June resulted in replacement of warm, dry, continental air masses by cool, rainy, maritime conditions.

Poleward displacement of the 700-mb jet stream was abruptly halted in July; and in the eastern United States the jet even moved southward, against the normal seasonal trend. This was associated with development of another strong block in northeastern Canada and a deeper than normal mean trough along the East Coast of the United States. The result was an unusually high frequency of both fronts and active cyclones, accompanied by below normal temperatures and excessive precipitation, in the northern half of the nation east of the Rockies. Figure 5 shows that the mean frontal zone was located in the central part of the United States, while there were as many as 23 days with fronts in Kentucky and Virginia. This July was the coolest in over half a century in portions of the North Atlantic States, the Great Lakes regions, and the northern Plains. It was also one of the cloudiest and rainiest Julys on record for much of the northeastern quarter of the country, with many stations reporting precipitation on 20 or more days during the month. In contrast, warm dry weather accompanied an upper-level high over the southern Plains and lower Mississippi Valley. Fort Worth, Texas, reported an average maximum

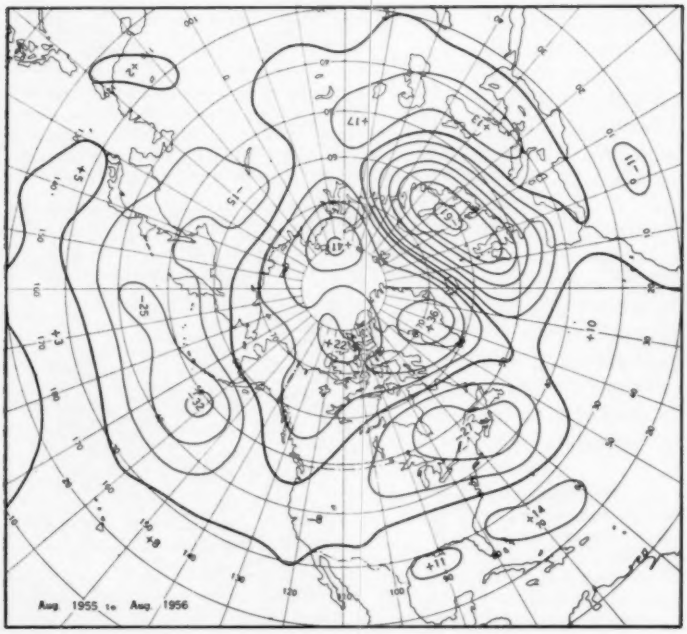


Fig. 6. Mean 700 mb. height difference (in tens of feet) from August 1955 to August 1956. Large changes were associated with marked reversal of the general circulation.

temperature of 101° F and a monthly mean departure of 4 degrees above normal.

The major features of the weather and circulation showed a high degree of persistence from July to August 1956, as is frequently the case at this time of year. During both months the weather in the United States was generally cool and wet in the North, warm and dry in the South, and cool in the West. At the same time mean troughs were located in the eastern Pacific, along each coast of the United States, and near the coasts of Europe and Japan. Blocking ridges dominated the circulation in the northern portions of Canada and the Atlantic, thereby preventing any significant poleward extension of the belt of subtropical highs. As a result both the zonal westerlies and the subtropical easterlies were depressed south of their normal latitudes. These circulation features were unfavorable for tropical hurricane activity in the United States, and the only storm which did form during the month, Betsy, remained in the Atlantic Ocean throughout its life history.

This was in marked contrast to August 1955 when four tropical cyclones developed, and hurricanes Connie and Diane inflicted great damage upon the Northeast. The difference in mean 700 mb height between this August and that of a year ago is portrayed in figure 6. Most striking are the large height increases in polar regions, associated with blocking, and the extensive belt of height falls at middle latitudes. Of special importance was the acceleration of the westerlies in the eastern United States, which diminished the chance of any hurricane striking the North Atlantic coast and caused last summer's tropical regime to be replaced by this summer's cool one. An even more pronounced change in circulation occurred over Europe, where heights at 700 mb were as much as 610 ft below last year's values (fig. 6). This was accompanied by a decided reversal in weather, from warm and dry during the summer of 1955 to a cool stormy regime with record-breaking rains this summer.

Fall

During the fall season a series of marked month-to-month and week-to-week reversals in weather and circulation occurred. The change from August to September was effected by westward displacement of mean troughs and ridges throughout the hemisphere. The resulting September pattern was a familiar one, consisting of a stronger than normal ridge in the West and a deeper than normal trough in the East. This circulation

(*Continued on page 33*)

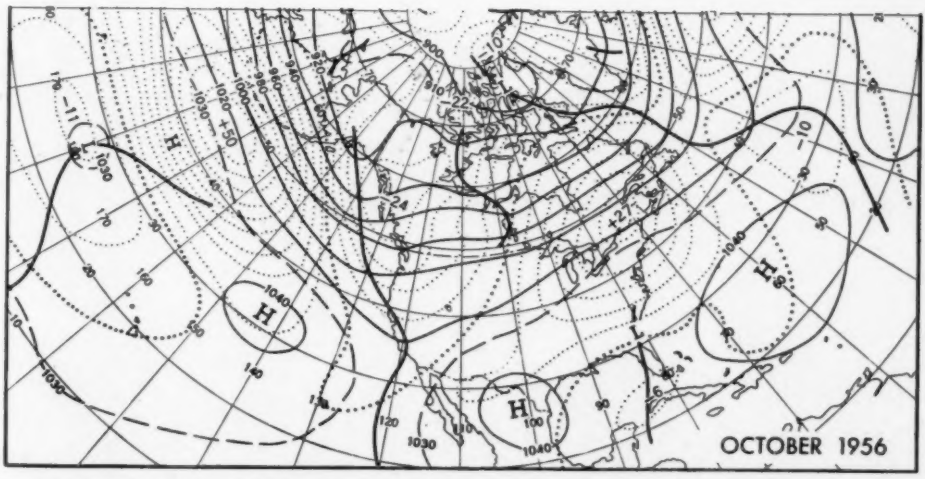


Fig. 7. Mean 700 mb. height contours with departures from normal superimposed (both in tens of feet) for October 1956. Pronounced Pacific ridge led to strong development of west coast trough and elimination of east coast trough except in Florida.

Tornadoes and Tornado Research in 1956

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Severe Local Storms Forecast Center,
Kansas City, Missouri

The funnel of the Cedar Rapids, Iowa, tornado on 28 May 1956 at 1701 CST was snapped by L. F. Langhurst of Solon, Iowa. The camera was 6 miles from the funnel and pointed east.

THE number of tornadoes reported during 1956 was near the record number recorded in 1955 and the locations of these destructive storms are shown on the map, the arrows showing the paths. About 850 tornadoes, including waterspouts, funnels not reaching the ground, and a few large dust devils have been reported to the Weather Bureau's Office of Climatology this year. These tornadoes and associated storms caused the loss of about 100 lives. It is interesting to note that even though the number of occurrences was nearly a record, the loss of life was less than half of the average for the past 41 years. In spite of greatly increasing numbers of tornadoes reported, the small loss of life during the past three years is generally believed to be at least partially due to the vastly improved forecasting and warning services. Because of a change in the manner of reporting the value of estimated property damage in 1956 by the Office of Climotology, dollar figures are no longer available.

A characteristic of climatological data on tornado occurrences during the past several years has been the large number of tornadoes reported as compared to any annual normal or average. In 1888, Finley [1] found the average annual number of reported tornadoes in the United States to be 146, based upon reports over a 10-year period from 1878–1887. Climatological records are evidently incomplete from that time until 1916.

A more recent study [2], based upon occurrences from 1916–1950, showed the mean yearly number of tornadoes to be 149, showing remarkable agreement with the pioneer, Finley, in this field. However, since this time there has been a remarkable increase in the number of tornadoes reported. This is due to an increase in and a spreading out of the population, the increase in the number of weather stations, improved communications facilities, but most of all to increased interest in the tornado problem. A yearly summary since 1949 plus a summary of prior periods of reported tornadoes and lives lost are shown in the table.

One of the problems in recording tornado occurrences for climatology is that the tornado is a very localized storm which is only infrequently observed by weather observers. Thus the climatologist must rely upon outside sources for tornado reports and, if he does not receive the report, it obviously cannot be recorded. The photo shown here was taken of a tornado 10 miles from Cedar Rapids, Iowa, last May and shows an unusually large amount of cloud detail for a tornado photo. This tornado was not reported to a Weather Bureau Station until after the climatological data for May had been published. Consequently, it is not listed in the May tornadoes, but will be included in the annual *Climatological Data, National Summary*. Tornado reports, indicating location, time, movement, and other pertinent data, especially photographs, should be sent to the nearest Weather Bureau office.

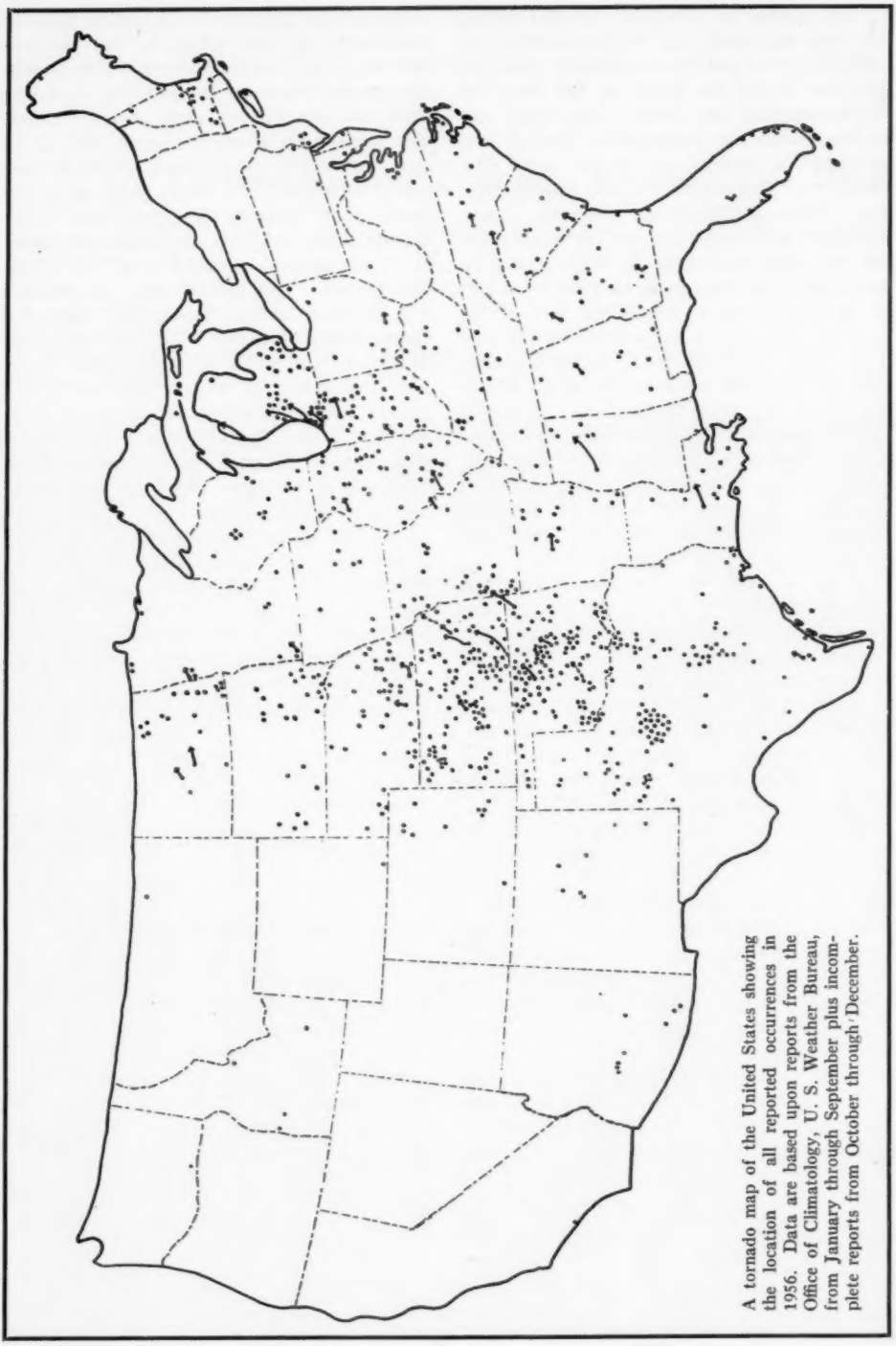
The first severe February tornado outbreak to strike Illinois since 1888 developed during the early morning hours of 25 February 1956. This tornado evidently formed in Missouri, just west of St. Louis, soon after midnight. These storms continued eastward during the night and the last disturbance was reported between Dayton and Columbus, Ohio, at 0630 EST. All together 25 tornadoes were reported along this storm path, but only 6 persons were killed.

One of the most destructive tornado situations of the year occurred on 2 April. Funnels first formed at 0300 CST in southwestern Oklahoma. Severe thunderstorms continued throughout the morning in Oklahoma and tornadoes developed again in mid-afternoon. During the late afternoon and evening, tornadoes struck over many sections of Oklahoma and Kansas, with spotty developments into Nebraska, Missouri, Iowa, and Illinois. While property damage was very extensive from some 28 tornadoes, only nine lives were lost and 150 injured.

The most devastating outbreak of twisters of the year occurred on 3 April and was actually a continuation of the same storm setting

	1878–1887*	1916–1950*	1950	1951	1952	1953	1954	1955	1956**
Tornadoes	146	149	213	304	273	542	702	874	850
Lives Lost		227	70	34	230	516	35	125	97

* Average. ** Estimated from incomplete reports.



A tornado map of the United States showing the location of all reported occurrences in 1956. Data are based upon reports from the Office of Climatology, U. S. Weather Bureau, from January through September plus incomplete reports from October through December.

of the previous day. Tornadoes occurred just after midnight on 3 April in Kansas, Missouri, and Oklahoma. Around noon, they developed in southeastern Arkansas and in southern Wisconsin. Tornadoes then continued throughout the afternoon and evening in Michigan southward into Mississippi. The 38 reported tornadoes and associated storms resulted in the loss of 36 lives, 614 injuries, the destruction or serious damage to over a thousand buildings, and property damage amounting to several millions of dollars.

Michigan was revisited by another serious outbreak late in the afternoon of 12 May and continued into the early morning. Nineteen tornadoes were reported in Michigan where the damage was most extensive. One funnel passed directly over the Muskegon, Michigan, Weather Bureau station at 0506 EST, 13 May, at an estimated height of 100 feet. This storm situation moved eastward during the evening through Ohio, the Cleveland-Akron area, into Pennsylvania. These storms caused the loss of 11 lives, 276 injuries, and property damage of over $15 million.

The most death-dealing individual tornado of 1956 hit near Birmingham, Alabama, on 15 May. This storm was associated with an instability line which moved across the state during the day causing extensive property damage from the wind, hail, and rain. The tornado developed along this instability line striking the outskirts of Birmingham at 1500 CST. Twenty-five people were killed, 200 more were injured; nearly 400 buildings were damaged or destroyed; and over a thousand persons were left homeless.

Another tornado outbreak occurred on 29 October, unusual, in that a number of tornadoes developed as far north as Nebraska where only three had been reported during October in the period between 1916 through 1955. This situation spawned at least a half-dozen tornadoes in Nebraska, some of which were very destructive. One was observed at 1645 CST from the Weather Bureau station in North Platte. As this tornado passed some 5 miles to the south of the station, hailstones as large as 3½" in diameter fell at the airport. One of the interesting features is that all hail, including many reports of baseball size, occurred north of the tornado track. (This was noted in many descriptions of tornado occurrences in the 19th Century.) Also, the North Platte tornado, over a 20-mile track, gradually increased in areal extent from a single tornado, to two tornadoes, and finally to an enormous, devastating whirl about 0.75 mile wide just before it dissipated. There was evidence that several smaller funnels occurred just south of the main vortex.

Tornado research continued at an accelerated rate during 1956. Oklahoma A. & M. College and the A. & M. College of Texas conducted extensive surveys of tornado damage. The objective was to provide basic data from which a physical model, or models, could be developed. The Drumright, Oklahoma, storm which developed late in the afternoon 2 April was particularly good for damage survey work, and Don Dickson of Oklahoma A. and M. has compiled some excellent data in this connection. Some groups are continuing their work on basic research, while others are further exploring synoptic associations in order to learn more about the cause of tornadoes.

The Weather Bureau Tornado Research Airplane Project was a first attempt to secure aerological data in the tornado environment on both the synoptic and meso-scale. The purpose was to obtain some much needed facts about the causes and characteristics of tornadoes and their environmental conditions. Mr. James Cook, Jacksboro, Texas, flew his specially instrumented F-51 into tornado areas to secure temperature and humidity gradients through both the vertical and horizontal planes. Forty flights were conducted within tornado forecast areas or in the vicinity of active tornadoes. The flights were carried out from April through August, using Kansas City as the operational base most of the time. While a considerable amount of valuable data have been compiled, time has not permitted detailed analyses of these data. An important finding of the project during 1956 determined that, with careful planning, routine flying into tornado forecast areas is feasible.

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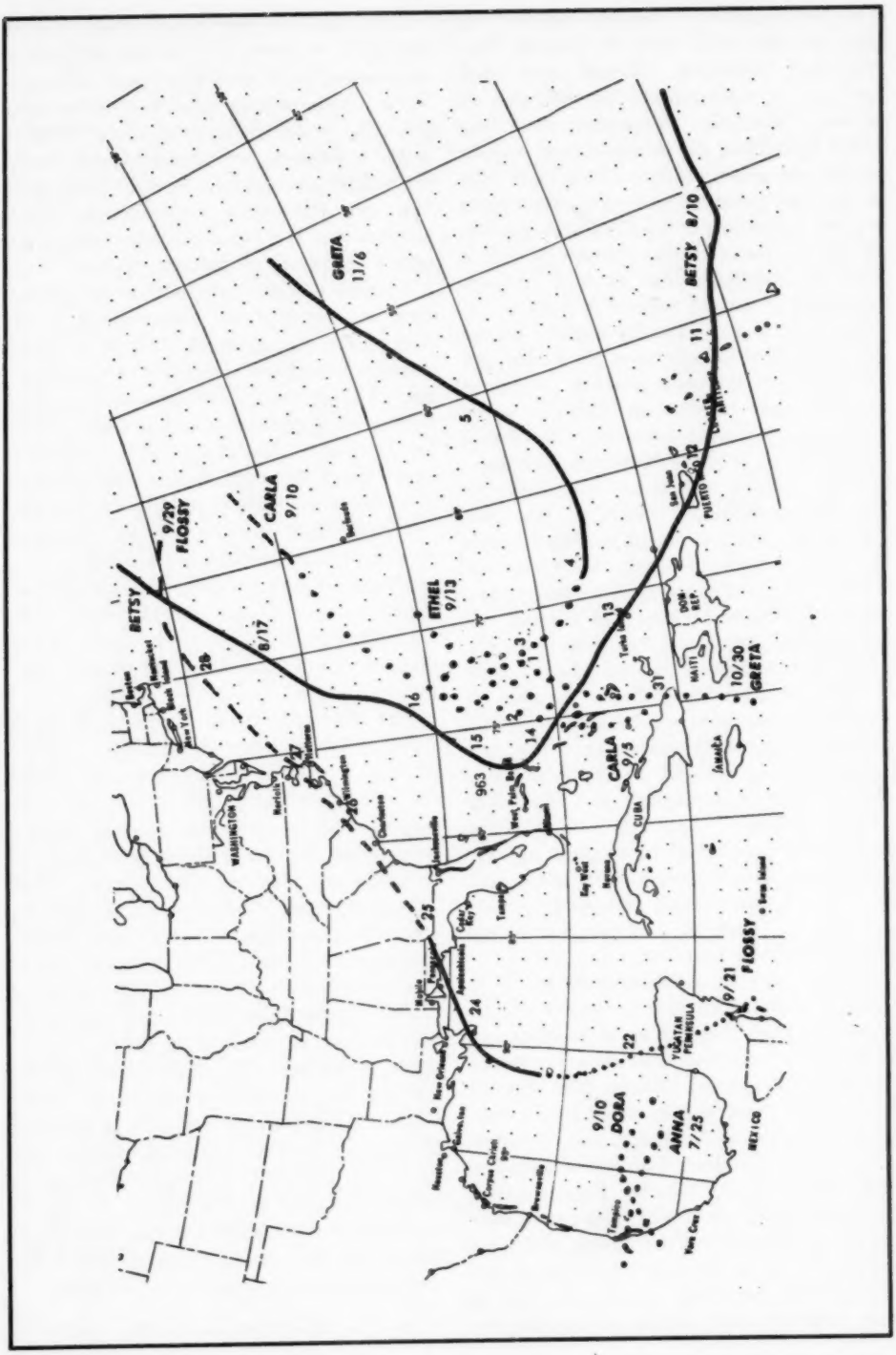
BETSY
9/29
FLOSSY
CARLA
9/10
8/17
ETHEL
9/13
GRETA
11/6
BETSY 8/10
10/30
GRETA
CARLA
9/5
CUBA
HAITI
9/21
FLOSSY
9/10
DORA
ANNA
7/25
YUCATAN
PENINSULA
MEXICO
963

The 1956 Hurricane Season

WALTER R. DAVIS, *U. S. Weather Bureau, Hurricane Forecast Center, Miami, Florida*

ONE of the lightest hurricane seasons of recent years in the Atlantic, from the standpoint of the number of storms and their intensity, occurred in 1956. A total of seven storms developed and three of those reached hurricane intensity, one for only a few hours. In addition, six tropical depressions were tracked that did not develop sufficient strength to warrant the issuance of advisories.

All storms of this season were small, as compared with most storms of other years, and none could be classified in the severe category (120–150 knot sustained wind). Greta, however, developed into this category for a short period while northeast of Puerto Rico. The seven storms of this season compare with an average of 9.8 during the past 20 years. In 1952 there were only six tropical storms, though their average intensity was greater than this season.

TROPICAL STORM OF 12–14 JUNE

A tropical storm developed in an easterly wave and beneath a cold low aloft about 100 miles off the Louisiana coast during the night of 12–13 June and moved inland over southeast Louisiana on the 13th.

It caused general rains over the middle Gulf states to end the drought situation. Southeast Louisiana, southwest Alabama, and most of Mississippi received 2 to 7 inches of rain, and lesser amounts occurred over the remainder of these states and Arkansas.

The highest wind reported was 55 mph from Grand Isle, Louisiana, and the lowest observed pressure was 29.66 inches at Moisant Airport, New Orleans, and McComb, Mississippi.

HURRICANE ANNA 25–26 JULY

An easterly wave passed through the Lesser Antilles on 20 July, continued westward across the Caribbean, and intensified to storm proportions in the Bay of Campeche during the afternoon of the 25th. In fact, a weak circulation probably developed during the night of the 24th while moving across the Yucatan Peninsula.

Reconnaissance aircraft located a center on the morning of the 26th with lowest pressure of 991 mbs (29.26 inches) and highest winds of 50 knots in the northern semicircle. The center moved inland early that afternoon a little south of Tampico, Mexico, giving lowest pressure of 29.60 inches and maximum wind of 70 knots (81 mph). Hurricane force winds probably existed only a short time before the storm passed inland.

No casualties nor injuries were reported. Many houses in the slum sections were blown down and roofs from some of the better homes were blown off.

HURRICANE BETSY 9–19 AUGUST

The first signs of the development that finally grew into hurricane Betsy were noted on August 9th when the M/T Marisa reported: "At 1218GMT passed through trough of tropical storm in position 14.05N and 49.05W. At 1200 GMT 1008 mbs wind force 10 very high wild sea heavy squall."

Reconnaissance aircraft on the 10th found a very small hurricane with 120 mph winds near the center and lowest pressure 979 mbs. The eye was 10 miles in diameter and described as a very tightly closed pattern on radar. It moved towards the west-northwest at about 17 mph and the center passed through the central Lesser Antilles about midday of the 11th very near the island of Marie Galante. Damage was severe and 16 lives were lost. On Guadaloupe 1,000 houses were extensively damaged, all communications disrupted, and 50 to 60 per cent of the fruit trees lost. Loss to the banana crop was estimated at $3.5 million and total damage was about $10 million. Lowest pressure reported was 991 mbs (29.26 inches), and highest winds estimated 100–120 mph.

The hurricane moved from the French West Indies across the extreme northeast Caribbean and passed over Puerto Rico during the night of the 11–12th. All of Puerto Rico except the southwest portion experienced winds of 75 mph or higher. Highest wind reported in Puerto Rico was 115 mph in gusts at Ramey

Air Force Base on the northwest tip of the island. Property damage in Puerto Rico totaled $25.5 million and 9 deaths were reported.

Hurricane Betsy continued on a west-northwest course at about 17 mph, passed near Turks Island, B. W. I., early August 13th and very near and slightly east of San Salvador, Bahamas, during the early evening of the same date. Winds of 132 mph were reported at San Salvador and 5 inches of rain fell in 5 hours. Several houses were demolished and most of the churches lost their roofs, but there were no casualties.

The hurricane slowed in forward speed on the 14th and 15th some 190 to 250 miles off the south Florida coast and began a gradual recurvature, and by the 16th it was moving towards the northeast and had accelerated in forward speed to about 20 mph. The hurricane began to decrease in intensity on the 16th and by late afternoon of the 17th had dropped to an estimated 80 mph, and the eye was becoming poorly defined when located off Nantucket, Massachusetts, and moving northeast about 23 mph. The last advisory was issued on the morning of the 18th as the storm had become more extra-tropical in character. During the ensuing two days it moved about due eastward and gradually lost its identity.

The hurricane successively came within range of the radar facilities at San Juan, the Air Force missile range stations in the Dominican Republic and the Bahamas, and Navy radar at Miami. With the addition of reconnaissance by the Air Force and Navy and the upper-air soundings near the hurricane track from the Air Force missile stations in the Bahamas, the hurricane was still a problem child from the tracking and forecasting standpoint due to its rapid movement and closeness to the Bahamas and the Florida east coast. At 1700 on the 13th hurricane warnings were ordered for a portion of the southeast coast of Florida, because at that time it was apparent with the direction of movement and rate of advance that squalls could develop by morning of the 14th and consequently hamper precautionary measures. By morning of the 14th, however, a northward turn was developing and further threat was on the wane. It was not until approximately 24 hours later, during the slow recurvature, that all threat to the U. S. mainland had passed.

Total damage is estimated at $35.6 million, including $100,000 in the Bahamas, and there were 40 deaths as a direct result of the hurricane.

Tropical Storm Carla 5–11 September

The first signs of tropical storm Carla may be traced to the early morning of September 5th when a very weak circulation showed up in a weak easterly wave that was moving into the southeast Bahamas. This circulation drifted slowly north-northwestward and by morning of the 6th was located in the vicinity of latitude 24 N longitude 75 W. Considerable shower and thunderstorm activity occurred on the 5th and 6th over south Florida, the Bahamas, and in the area over the Atlantic 300 to 400 miles east and north of this weak center.

By early morning of the 7th, the weak circulation had moved northward, then a slow drift towards the north-northeast and northeast occurred on the 7th. Some deepening had taken place and the field of strong winds had expanded to cover an area 300 to 400 miles in diameter with highest winds of 35–45 mph mainly to the east and south of the center by the morning of the 8th.

A strong southeastward push of polar air was taking place in the eastern United States and the attending cold front passed off the east coast during the morning of the 7th. On the 8th interaction between the 1034 mb high pressure area centered over the Great Lakes region and the tropical low over the Atlantic was causing strong northeast winds from the central Florida coast northeastward along and off the Georgia and Carolina coasts. The area of strong northeast winds spread northeastward along and off the New England coast as the low moved to a position near Latitude 32.5 N longitude 70 W by the morning of the 9th. Reconnaissance aircraft on the morning of the 9th located an ill-defined center at latitude 32.1 N longitude 69.5 W. Highest winds were estimated at 30 knots. During the afternoon about the same conditions existed as far as the center was concerned; however, maximum winds of 40–50 mph were found to extend for 200 miles to the west and northwest. Highest winds to the east and south were about 40 mph.

During the formative stages of Carla, she was never in a favorable location with respect to the upper-level high pressure cell to augment deepening before taking on extratropical characteristics due to the strong intrusion of polar air on the 7th, 8th, and 9th.

Tropical Storm Dora 10–12 September

Evidence of a circulation in the upper-air appeared on September 7th in the Yucatan Peninsula area and on the afternoon of the 10th reconnaissance aircraft found a rather large area in the Gulf of Campeche with scattered rain squalls. Highest wind was 35 knots and lowest pressure 1010 mbs. On the afternoon of the 11th the aircraft located a center of 1004 mbs and reported maximum winds of estimated 65 knots.

This storm has not been classified as a hurricane since the 65 knot wind was an estimate and not a measurement and it is not believed that the required pressure gradient for this wind existed. The following morning reconnaissance aircraft found the same minimum pressure with maximum winds of 50 knots. The center moved inland near Tuxpan, Mexico, around noon on that day with lowest pressure 1002 mbs and highest winds 35 mph.

Tropical Storm Ethel 11–13 September

A weak circulation was noted in the Great Exuma Island area in the Bahamas on the afternoon of September 11th. This circulation moved north-northeastward in the Atlantic and gradually intensified during the ensuing 24 hours. Reconnaissance aircraft found a fairly well-developed eye about 20 miles in diameter on the afternoon of the 12th and reported a maximum wind of 66 knots. Winds of 30 knots were encountered outward 30 to 100 miles in all directions.

The storm may have supported winds of this velocity for a short time, however, since development took place under a broad polar trough, it had assumed extratropical characteristics and lost intensity by late afternoon of the 13th.

Hurricane Flossy 21–30 September

This was the only hurricane to reach the coast of the U. S. in 1956. Its origin is not definitely known. Squalls were reported in the Pacific Ocean south of Guatemala on the 20th and the initial impetus either came from there or from the Caribbean.

Pressures were below normal for several days over the western Caribbean and on the afternoon of the 21st a well-developed circulation showed up over the Yucatan Peninsula which moved into the Gulf of Mexico near Merida. It moved northward over the Gulf and gradually intensified reaching storm intensity on the afternoon of the 22nd. It increased considerably in size but the intensity near the center increased rather slowly. Hurricane intensity was reached at midday of the 23rd when the center was some 125 miles off the southeast Louisiana coast. It turned sharply towards the east-northeast during the afternoon, crossed the Mississippi delta a short distance north of Burrwood near Pilottown early on the 24th. The blow probably reached maximum intensity at this time with highest wind of 84 mph at Burrwood and lowest pressure of 29.03 inches. An oil rig a short distance west of Grand Isle, Louisiana, reported highest wind of 83 mph with gusts to 95.

The center passed near and a little south of Pensacola, Florida, with maximum wind of 64 mph, gusts to 88, and lowest pressure 28.93 inches. The eye of the hurricane passed over Ft. Walton, Florida, a short distance east of Pensacola, with lowest pressure of 28.95 inches. Winds of near-hurricane force occurred along the northwest Florida coast eastward to Panama City. It continued east-northeastward into Georgia on the morning of the 25th and rapidly filled and became extratropical, though remaining a rather vigorous storm until it passed out to sea near the Virginia Capes on the 28th.

At least three tornadoes occurred in northwest Florida in connection with this storm, one well in advance of the center, near Wewahitchka in Gulf County about 0300 on the 24th. Several buildings were destroyed and others damaged. Another was reported in Jefferson County and a third in southern Suwanee County during the evening of the 24th. No major damage was reported from these. Another tornado occurred at Hilton Island near Savannah, Georgia, but caused only minor damage.

The highest tide due to this storm appears to have been 4 to 5 feet, although it may

(Continued on page 32)

A Dust Bowl Farmyard of 1956. Wide World photo.

Drought in 1956

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HISTORY OF THE DROUGHT

IT seems very probable that 1956 will go down in history as one of the worst drought years of record in the United States. Precipitation for the year amounted to less than 75 per cent of normal over approximately one-third of the United States and was less than 50 per cent of normal over a surprisingly large area in the Southwest (see fig. 1). These moisture deficiencies occurred for the most part in areas where the drought condition has already existed for several years (see fig. 2).

By means of 5-year moving averages of total annual precipitation there has been shown to be some evidence that the current drought began in 1946 in southwestern Texas, southern New Mexico, and over most of Arizona, and since that time it has rather sporadically spread northeastward as far as Iowa.

It has been pointed out that cyclical variations as studied by means of 5-year running average annual precipitation appear in many station records. However, there is little definite evidence of periodic variation of drought which is consistent from one station to another or from one part of the record to another. This study further concludes that the severity of the present drought in the southwestern United States has in general equalled or exceeded any other drought in the same area since precipitation records began in the middle 1800's. Tree-ring data suggest that there have been no droughts of substantially

greater severity in that area since about 1670, and perhaps not since 1570.

What is Drought?

Drought is difficult to define in a manner which is suitable to the various pursuits which it affects. The agronomist is concerned primarily with its effects on growing plants. The hydrologist's thinking connects it with underground and surface water for use by industry and commerce as well as with supplies for irrigation. Other special fields have additional interpretations of a moisture deficiency.

It is obviously very difficult, if not impossible, for the meteorologist to assign a definition to drought which will fully meet the needs of these various groups. The only reasonable approach remaining appears to be that of regarding drought as a climatic anomaly—a relatively temporary departure of the climate from the normal or average climate toward aridity. In this sense drought becomes a climatic anomaly characterized by a deficient supply of moisture—deficiency in turn being defined in a particular manner which takes account of unusual water requirements. This deficiency may result from below-normal rainfall, poorly-timed rainfall, excessive evaporation and transpiration or, more likely, a combination of all three. While this may not be an entirely precise definition, it is a useful one and some studies are underway based on the above premise.

Crop Production and Drought

The 1956 drought, when measured by the deficiency of total annual rainfall, covered parts of the Southeast and most of the area extending westward from the central and lower Mississippi River. However, when measured in terms of serious crop curtailment, the total area was limited to the central and lower Great Plains and a few adjacent areas.

In the western portions of the drought area precipitation for the period 10 October 1955–1 April 1956 (fig. 3) ranged from less than 25 to about 50 per cent of normal. The lack of moisture and the damaging dust storms in February and March caused the total loss of a large acreage of winter wheat.

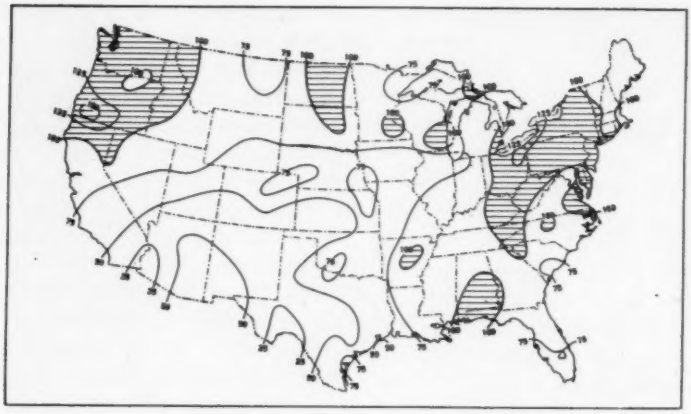
April rains brought some relief to eastern portions of the area, and rains in May and June were beneficial in scattered areas, but widespread general rains were lacking.

July brought more substantial relief to northern and eastern portions of the drought area, but Texas and parts of Oklahoma and Kansas remained extremely dry. In some sections of Texas the first seven months of 1956 were the driest since 1934. The summer as a whole was dry with less than 50 per cent of normal rainfall in much of Kansas and parts of Oklahoma and hot (fig. 4). In areas favored by rains benefits were limited by intense heat and the shortage of subsoil moisture resulting from large accumulated rainfall deficiencies. Similar weather conditions prevailed throughout most of September and October.

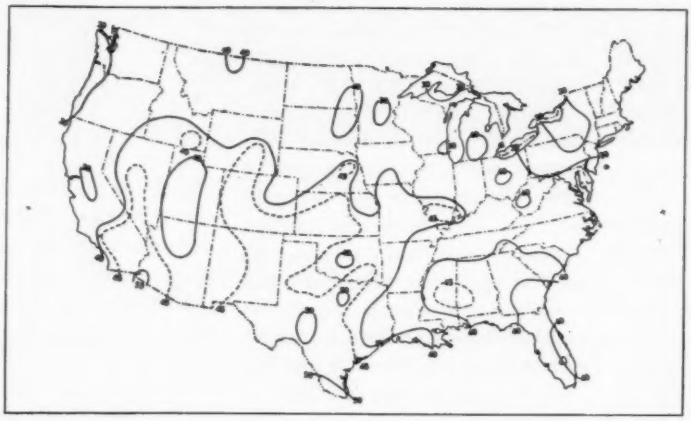
Dryland crops in most of the drought area steadily declined after the middle of June. The decline of pastures, virtually non-existent in eastern Nebraska and from Kansas southward by the end of the summer, the discouraging prospect for feed crops, and the dwindling water supplies resulted in heavy cattle marketing, even foundation herds being sacrificed in some of the worst areas.

General rains fell over the drought area during the closing days of October and the first few days of November, ranging from heavy in eastern portion to light to moderate in western portions. Following these rains moisture was sufficient in large areas for seeding, germination, and growth of fall grains. Pastures responded well to the rains, particularly in the southeastern portion of the drought area, and marketing of livestock was sharply reduced as hopes for winter grazing revived.

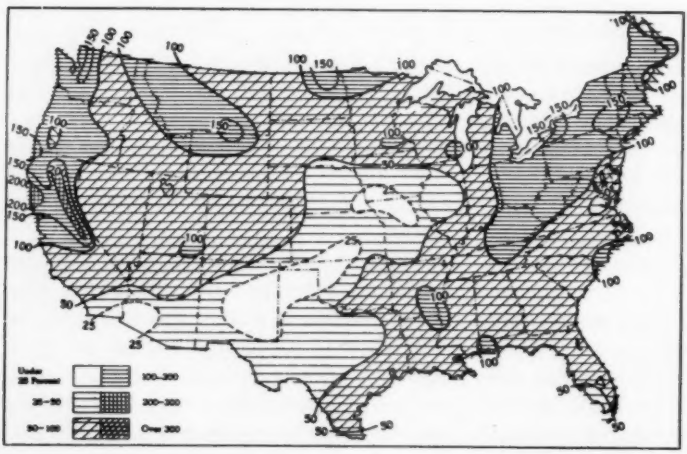
Generous rains with little runoff about the middle of December further improved moisture conditions in eastern Texas, and central and eastern Oklahoma and Kansas. The year ended with severe drought persisting in western and northwestern Texas, New Mexico, the Panhandle and extreme northwestern por-



Percentage of normal annual precipitation 1956. Shaded areas normal or above. USWB chart.



Number of months deficient precipitation, 1952–1956. USWB chart.



Percentage of normal precipitation: 10 October 1955–1 April 1956. USWB chart.

tions of Oklahoma, most of western and southwestern Kansas, and southeastern Colorado.

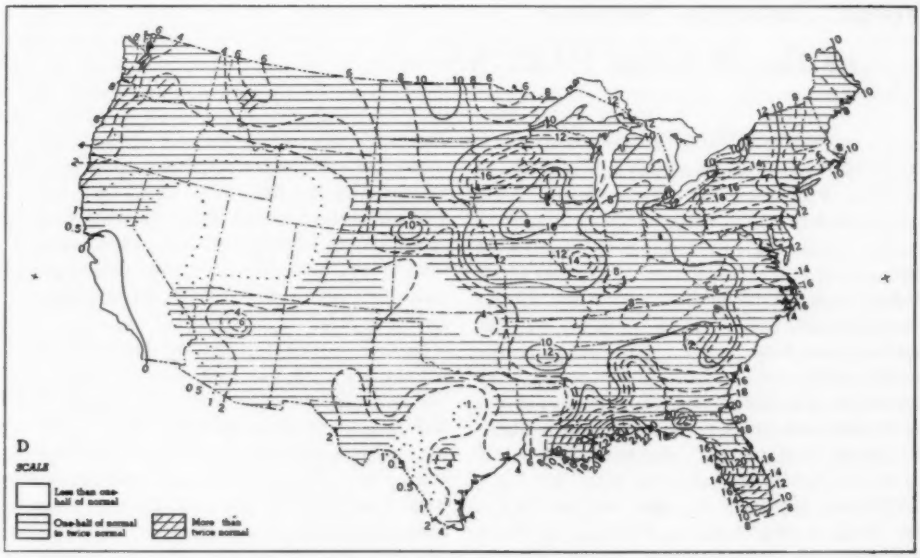
Water Supply

Water shortages resulting from the prolonged drought are critical in many sections of the drought area. Some of the large springs in the area, have gone dry; Comal Springs near San Antonio, Texas, dwindled and finally died in June—for the first time in at least 300 years. Trees that were old when the first white settlers came to Texas are slowly dying for lack of water. Many cities and towns as well as farmers and ranchers are hard hit by the water shortage. The rivers and lakes that they depended upon have either gone dry or reached critically low levels. One of the largest cities affected was Dallas, Texas, where some enterprising people are selling water by the gallon like milk. Irrigation water was inadequate in many districts of the Southwest. Many streams in the Great Plains and Southwest fell to near record low levels during the summer and fall and some smaller streams dried up.

A study of low river stages in large areas of the mid-Continent shows how communities and industries dependent on normal river flow for their water supply are affected. The case at St. Louis, Missouri, is an example of conditions over an area of approximately 700,000 square miles. By mid-October the stage there had dropped to minus three feet, and prospects were that unless drought-relieving rainfall occurred in the next two months, lack of water would necessitate complete suspension of navigation on the Mississippi upstream from the Ohio River; could cause reduction in electrical generation in the greater St. Louis area to an emergency degree; and require severe curtailment of industrial operations in the metropolitan St. Louis area.

Drought Damage

A list of drought losses would include such items as crops, wages, taxes, soil erosion, expenses associated with water shortages, and many others. No attempt has been made to measure these losses in terms of dollars, but the total would undoubtedly run into the billions.



Total precipitation, inches, Summer season (June–August) 1956. USWB chart.

A 24-inch snowburst ties up the city of Erie, Pennsylvania, during Thanksgiving holiday 1956.

Some Notable Snows of the Winter 1955-56

South Buffalo Snowburst

A typical lake storm situation developed on 28 November 1955 and buried the southeastern shores of Lake Erie in a deep blanket of snow during the next 72 hours. A cold front trailing southward from a low moving across central Ontario passed Buffalo in the early hours of the 28th. A deep closed low aloft kept a cyclonic circulation in progress even though the low center moved northeastward to Labrador. A northwest flow of Arctic air crossed the open lakes, picked up moisture, and was forced aloft as it struck the shorelines and low-lying hills inland from the lake. Excessive snowfall resulted over limited areas near the Lake.

The towns just south of Buffalo were the hardest hit. Elma, a road center, measured 32″ in the 3-day storm, and Buffalo Airport, just six miles to the north, had 20″ to snarl airline traffic as well. The heavy snowfall also spread westward along the south shore of Lake Erie. Corry, Pennsylvania, had 16″ and Chardon, Ohio, 14″.

It is interesting to note that a storm of equal intensity hit the Erie, Pennsylvania, area at about the same time of the year in November 1956, creating a major industrial tie-up over the Thanksgiving Day holiday period.

Snowfall continued to be very heavy throughout western New York State after this early start. Little Valley, (1575′ above sea level), 55 miles south of Buffalo near the Pennsylvania border, reported a seasonal (1955–56) fall of 196.5″. The Boonville area to the north had the greatest total fall in New York State with 225.6″. And the snow removal commissioners of Syracuse (424′) had plenty of headaches handling the 146″ that were dumped on that communication and manufacturing center.

Dakota Blizzard

The early winter of 1955–56 on the northern Plains was one of the coldest of record; from mid-November until Christmas Arctic air dominated the scene with temperatures far below normal. Early in December a notable snowstorm and blizzard swept the open spaces of the Dakotas. Though the temperatures were not unusually severe nor the winds exceedingly high, the amount of snowfall was unusual during a blizzard condition.

A Colorado low formed on 2 December—by noon of the 3rd it was centered near Omaha and 24 hours later near Minneapolis. This rather slow movement permitted an unusually long period of precipitation over South Dakota on the 3rd and 4th. Amounts up to 1.55″ were recorded in the Sioux Falls area where 12″ of new snow fell. Measurements near 12″ were common throughout southern and eastern South Dakota. At Huron it was the sixth heaviest snow on record. High winds whipped the powdery snow, plugging roads and cutting visibility to zero at times. Many travelers were stranded at farmhouses along the highways. A closed low aloft intensified the cyclonic circulation around the low and southwesterly currents supplied sufficient moisture to give amounts well over one inch of water.

Texas Blizzard

A howling blizzard moved into the High Plains of the Texas Panhandle on the first day of February and held sway through the 5th. Snow in unprecedented amounts fell at several points close to the New Mexico border, while over most of the Plains a light snow was driven by 40–50 mph. winds so that drifting seriously interfered with traffic and business. As the precipitation band moved southeastward, snow changed to glaze with icing conditions reported as far south as Austin and San Antonio. Power lines came down, and traffic was at a standstill for many hours. Twenty deaths were attributed to the storm.

The chief instigator of the blizzard was a strong anticyclone over Idaho which maintained its intensity throughout the five-day period with a maximum pressure reported at 1,048 mb. The circulation around the high spread cold air southward over the Plains. At the same time a closed low aloft over Arizona-New Mexico was bringing moist air from the Pacific over western Texas. At the surface maximum temperatures in the Panhandle were about 20°, with nighttime readings just above zero.

The core of the heavy snowfall lay south of the Canadian River in Oldham and Lubbock Counties. At Plainview a fall of 24″ on the 4th brought the total cover to 30″. At both Lubbock and Amarillo, first-class Weather Bureau stations, the snow cover reached 13″ to establish new records. The greatest snowfall and deepest cover was reported by the cooperative observer at Vega (4,000′) with a reported total snowfall of 61″ and a cover of 33″ on the 7th. Snow cover did not disappear at Vega until the 19th. Vega's total monthly precipitation of 5.50″ was all registered, with the exception of .15″, during the blizzard period of 1–8 February. This figure is about four times the amount reported at surrounding stations. If the figures are correct, a local circulation peculiarity, similar to the lee shore lake snowburst mechanism, must have been set up to give such a continuous snow. But where did all the moisture come from?

New England's Snowiest March

Old timers never saw anything like it—at least not for several generations. It started to snow on the 16th of March, a date when most people Down East are looking forward to spring, and by the end of the month four major snow storms had piled up new snow cover records for March and also for so late in the season. At most localities it was the snowiest March since 1871 when Weather Bureau records commenced, and in many places in central and southeastern New England it was the snowiest month ever experienced. It should be pointed out that the famous Blizzard of 1888, also a March visitor, affected only the area from southern Vermont to Long Island Sound west of the Connecticut River. The snowfalls of 1956 were general throughout the entire region. Even Sydney, Nova Scotia, had a record March fall of 58″.

An energetic coastal storm moved northward from Alabama on the 16–17th accompanied by a strong southwesterly flow aloft which brought in adequate moisture. Soon after midnight of the 17th the center was off Nantucket with a central pressure of 972 mb (28.70″) as an easterly and northeasterly surface wind underran the moist southwesterly current aloft. Gales of 50 mph swept the area on the evening of the 16th, causing one of the greatest traffic snarls in the evening rush hour on record. Conditions were judged to be worse than in the Valentine Day's near-blizzard of 1940. Up to 19″ of snow were measured, and the gales whipped it into drifts five feet deep on highways.

While residents were still digging out, a new fall started on the 19th as an innocent-looking low moved eastward through the Ohio Valley to the Delaware coast. Then turning northeastward, it

picked up moisture from the relatively warm Atlantic and dropped a new load of snow flakes on the immediate coastal sections. This was among the heaviest individual snow storms on record for eastern Massachusetts. Blue Hill Observatory measured a fall of 19.4" and 15" falls were common. Putnam in northeastern Connecticut had 20". Piling on top of the St. Patrick's Day fall of 12–15", it gave the snow removal forces the greatest test of their careers in the Boston area.

On the 24th another snow storm dumped 4 to 12" on central and southern New England. Cyclogenesis had taken place in the Ohio Valley on the 23rd and a band of light snow broke out to the north of the path in Pennsylvania and New York. Once the center reached the coast, a deep trough developed and this induced a strong flow aloft from the south-southwest, tapping again the moisture source of the Gulf of Mexico and the Atlantic.

The fourth major storm in two weeks visited Massachusetts and northern New England on the 29–30th with an additional blanket of 3–7". This storm developed from a secondary disturbance off the Virginia Capes as the parent low faded out over Ontario. The center passed very close to Nantucket at a rapid pace and the snowfall was greatest in Maine.

It is important to point out that each of these four historic snow storms had a different origin, again emphasizing the very difficult job that the forecaster in this region faces each time he scans his weather maps looking for possible snow situations.

Large areas of central New England received 50" or more snowfall in March 1956. Snow cover generally reached 24" after the second storm—in many places a March record and practically everywhere a record for so late in the season. It is significant to point out that Norfolk, a traditionally snow spot in northwestern Connecticut only 80 miles from New York City, broke all monthly records with a total March fall of 73.6". Its deepest cover, 47", was measured on the 20th and at the end of the month it was reduced to only 42". Norfolk is at an elevation of 1380', very close to that of the peak of the Empire State Building in New York City. The seasonal fall at Norfolk amounted to 177.4", breaking the all-time Connecticut record of 133.4" held by Cream Hill in 1915–16. In the current season Cream Hill had a total of only 108.8".

New U. S. Seasonal Record

A new all-time United States record for total seasonal snowfall was established at the 5,500-foot level at Mt. Rainier, Washington, from July 1955 to June 1956. The Paradise Ranger Station on the slopes of the 14,048-foot mountain has long been known as a snowy spot, but continuous records have not always been taken in the snowiest years of the past. A total of 1000.3" was measured at the National Park station. Estimates of the State Highway Department ran even higher. The Ranger Station is ideally suited for maximum catch of precipitation. At 47° N. it is astride the normal track of cyclones entering the continent from the Pacific Ocean, and preciptation at that latitude is normally near a maximum at the 5,000–6,000 foot level. The previous seasonal record for the United States, 884 inches, was established at Tamarack, California, elevation 8,000 feet, in 1911.

The snowpack in the Western mountains was generally heavy in Washington, Oregon, and northern California, despite a dry spring. But southeast of a line from Santa Barbara to Salt Lake City and thence east to Cheyenne, the snow pack and resultant run-off were far below normal and posed a serious water problem for much of Nevada and all Utah, Colorado, Arizona, and New Mexico.

Progress (*Continued from page 7*)

Rico. In addition to holding meetings designed to bring their members up-to-date with respect to new technical developments, the branches have greatly increased their activity in conducting sessions devoted to discussions of the manner in which professional activities should be carried on. The Council requested of and received from the branch chairmen excellent guidance on several questions of profession-wide importance. It became evident that closer liaison between the branches and the national Society is essential and the AMS Executive Committee began to study methods of maintaining closer contact on a routine basis.

The membership of the Society increased by 798 in 1956. Of these, 172 were regular members, 240 were professional members, 62 were student members, and 313 were associate members. The number of corporation members was increased from 45 to 56 during

the year. By the end of 1956 the total membership of the Society had increased to 5885.

The Glossary of Meteorological Terms, to be prepared by the AMS under financial support from the military services and the Weather Bureau, was ready for final editing by the end of the year. The revised Membership List, containing names of our members as of November 1956, was sent to the printers for publication as Part II of the AMS Bulletin of January 1957.

An unprecedented event in AMS history took place at Boston in October 1956 when a full three-day Council Meeting was held, for the first time not in conjunction with one of the Society's National Meetings. It was decided that the meeting would be devoted, insofar as possible, to discussions of and action on matters of major policy affecting the future course of the Society.

The Council voted that the Society adopt a policy of informing the United States Congress and appropriate governmental officials of the Society's position on meteorological matters of national importance; that consideration be given only to broad questions affecting the profession as a whole and the welfare of the Nation; and that any appearance of lobbying be avoided as well as matters which concern the internal operations of single agencies or are of interest only to meteorologists. The Council, in its first action under this policy, formed the committee to review needs in the field of weather communications. Also, recognizing that meteorological research is not progressing at a sufficiently rapid rate, the Council directed the Committee for the Encouragement of Meteorological Research, operating under a broadened statement of its function, to recommend appropriate key actions to the Council.

The Council discussed the professional and scientific stature of the field of meteorology as well as actions that might be taken to enhance public recognition of the areas represented by the AMS. The deliberations confirmed the need of articles for the *Bulletin*, written by appropriate experts, at a level of the bulk of our membership, discussing the present status and future prospects of various areas of meteorology and other matters concerning the profession and its relation to the public and general scientific fields. It was also decided that our committees would be requested to prepare statements for release by the Society on the current status and future prospects in specific areas of meteorology.

As indicated earlier, the Council acted on reports of the Committees on Industrial Meterorology and on Radio and Television relative to issuance of Certificates of Competence for Consulting Meteorologists and of AMS Seals of Approval for radio and television weather programs. In recognizing current deficiencies regarding the number of new students entering the field of meteorology, the Council also asked the Executive Secretary and the Committee on Weather Study Programs at the Elementary and Secondary-School Levels to recommend specific actions to the Council as to methods of bringing meteorology to the attention of secondary school students and to explore ways and means of securing financial support for an appropriate program.

On agreement as to the pressing need for more nearly adequate space for the Headquarters of the Society, the Committee requested the Treasurer and Executive Secretary to prepare specific proposals for a solution of the problem and to present a detailed picture of its financial aspects.

In review, it can be seen that the year was marked—if not by any major "breakthroughs" such as the introduction of a polar-front theory in the 1920's or the start of operational map production through use of electronic computers in 1955—by a sizeable number of specific events of considerable significance to our science and profession. In nearly all the areas of direct concern to our membership a gradual improvement could be discerned. The same process of gradual development was evident also in our Society. Nevertheless, in the long run, it may well turn out that the most important event was the decision of the Society (through its Council) that the AMS has gained the stature where it must now speak publicly for our profession and science. In doing so aggressively, thoughtfully, and with the guidance of our Code of Ethics and Standards, the Officers and Council are firmly convinced that the Society can be of outstanding assistance in advancing the status of meteorology in the Americas.

Weatherwatch

Early Winter Turns on the Heat—Drought Persists

DAVID M. LUDLUM, *Editor*

October was a relatively stable month in general circulation patterns and resultant weather conditions. It was generally warm east of the Great Divide, markedly so in the Mississippi Valley, and colder than normal in the Pacific and Mountain states. A low index type of westerly circulation predominated with a well-developed trough in the Western states and an equally distinguished ridge over the Atlantic Coast region—a combination which produced air streams with northerly and southerly components across the country.

November demonstrated no such stability. Studies have shown that there is less similarity of conditions and continuity of weather patterns from October to November than between any two other succeeding months. Though the wintry conditions which descended on the Rocky Mountains and Plains states during late October continued into the first days of November, thereafter there were shifts in the air flow from day to day with a varying temperature regime, and the precipitation patterns showed even less uniformity.

The main feature of all November pressure maps stemmed from the persistence of higher than normal barometer over the eastern Pacific Ocean and the Pacific Coast states. Coastal Washington exhibited the greatest plus departure, and the barometer averaged above normal over the Plateau where a Great Basin high featured most daily weather maps: from the 4th through the 12th and again from the 19th through the end of the month. The strength of the anticyclonic regime accounts for the fact that not one cyclonic disturbance entered the continent south of Alaska during the entire month. Thus, there was little air mass change. Stable anticyclonic conditions produced cold surface temperatures and fog in inland valleys for many days. At the same time a continued easterly flow from the interior down to the coast created a tinderbox condition in Southern California, the preliminary to the disastrous fires which broke out in December.

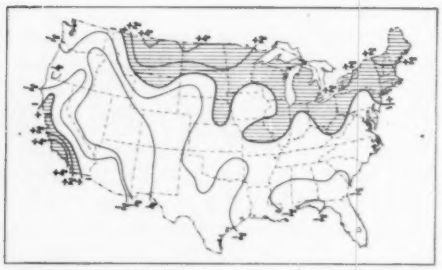
The lack of continued cyclonic activity within the borders of the United States was an outstanding feature of November. There were, however, three trough movements across the country of some consequence, all of them slow-moving and attended by light to moderate precipitation.

Cyclogenesis took place over Kansas on the 2nd, a long north-south trough started to move eastward, and finally reached the Atlantic Coast on the 9th. The second disturbance of the month formed in the Southwest on the 12th on a long front trailing south from Canada. It took a northeasterly track across the Upper Lakes and pushed its front to the Atlantic by the 17th. When over Upper Michigan on the 16th pressure dropped to 990 mb (29.24 inches), the pressure gradient tightened, and a typical November lake storm raged for a few hours.

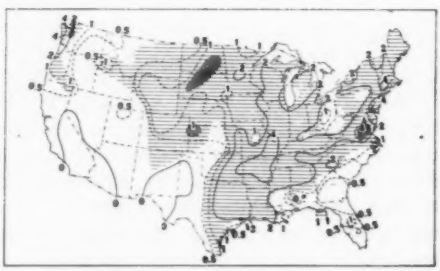
The third November storm formed in a similar manner in the Southwest on the 18th and was carried northeastward on a parallel track into Ontario where a central pressure of 970 mb (28.65 inches) developed. Cold Arctic air swept down behind the circulation and reached the Atlantic Coast during the night preceding Thanksgiving Day.

A spectacular snow storm accompanied the Arctic

MONTH OF NOVEMBER 1956



Departure of Mean Temperature from Normal in degree F. USWB chart.



Total Precipitation in Inches. USWB chart.

outburst in a limited area along the lee shores of Lake Erie and Lake Ontario. The cold winds had a long fetch across the relatively warm waters, and conditions were just right to set up a lake storm mechanism. For two days snow fell on the industrial city of Erie, Pennsylvania, burying it under an official 24-inch blanket and paralyzing its business and industry. Many Chicago-New York trains and trucks were stalled for two days. At the eastern end of Lake Ontario in New York amounts up to 40 inches were reported in the press.

DECEMBER—The last month of an interesting meteorological year was a notably warm one throughout all of the United States with the exception of a triangular area from Nevada westward to the coast and northwestward to Washington. There appeared two principal centers of abnormal warmth: one in Montana extended over most of the northern Plains, the other in the Southeast covered all the southern Appalachians. In South Carolina, it was the warmest December in 67 years, or since the all-time mild winter of 1889–90. New maximum monthly marks were set for December at numerous Atlantic Coast stations, and daily figures were shattered on many consecutive days.

The circulation features producing this remarkably mild start of winter show up readily on both the daily weather maps and on the mean monthly pressure charts. Sea level pressure averaged above normal except for a slight depression from the Great Lakes and middle Mississippi Valley eastward to the seaboard. At the 10,000-foot level pressure was above normal everywhere, and the westerlies that accompany this set-up were far north of their normal December position. This permitted a continuous flow of mild Pacific air into western sections and prevented any large-scale southward transport of Arctic air masses.

From the 8th through the 25th a western ridge-central trough-eastern ridge system prevailed in the upper-air flow. A strong Plateau high brought Pacific air masses around its northern periphery and plunged them southeastward into the Mississippi Valley. Thus, the air reaching the northern Plains was originally from a warm source and was further dynamically heated as it descended the eastern slopes of the Rockies. For the week ending 30 December, temperatures were as much as 24 degrees above normal in Montana, and the entire month averaged out 6 degrees above normal.

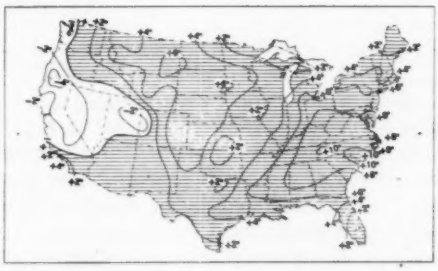
The unusual warmth in the Eastern States may be attributed to the strength of the Bermuda high, around whose westerly edge an almost continuous flow of southwesterly currents from the Gulf of Mexico carried tropical air northward to New England. The temperature isotherms in the East trended from southwest to northeast along the path of mean flow. For three consecutive weeks in the south-central Appalachians the mercury averaged 15 degrees above normal to accumulate a monthly surplus of 10 degrees at Charlotte and Knoxville.

The precipitation pattern resembles what one would expect from a western ridge-central trough-eastern ridge regime. Rainfall was heavy on the Northwest Coast where depressions from the Pacific were carried swiftly eastward by the strong west flow. Anticyclonic conditions over the Plateau kept that area almost rainless, and in the shadow of the Rockies from Minnesota to Texas and westward to Southern California practically no rain fell, further intensifying the drought which had now reached the proportions of a national disaster.

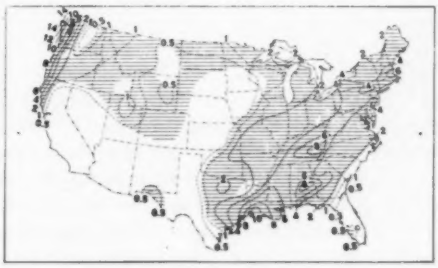
To the east of the central trough, southwesterly winds carried moisture from Louisiana to Massachusetts and rainfall was normal or above over all the central and northern Appalachians. The absence of cyclonic activity in the Gulf of Mexico gave rise to another dry area that extended southward from Cape Hatteras to include all Florida.

The pressure type which had characterized all the middle days of December began to break up on Christmas Day when the Pacific-Plateau anticyclone increased its intensity and expanded its influence. The western ridge over the United States moved eastward and northward to set up a western ridge-eastern trough pattern. Its northward extension into British Columbia and Alberta reached the sub-Arctic and shut off the flow of Pacific air which had kept the Plains states so mild. Now cold Arctic air flowed into the Great Lakes and Atlantic states on the heels of small depressions which formed on the Pacific-Arctic front over western Canada. A siege of wintry weather enveloped the Middle West and Northeast and produced some of the coldest January weather experienced in 20 years.

MONTH OF DECEMBER 1956



Departure of Mean Temperature from Normal in degree F. USWB chart.



Total Precipitation in Inches. USWB chart.

Hurricanes (*Continued from page 21*)

have been higher in localized areas. The heaviest rainfall reported was 16.70 inches at Golden Meadow, Louisiana, and 16.30 inches at Gulf Shores, Alabama. The intensity of rainfall gradually decreased as the storm moved northeastward, but 1 to 3 inches fell as far north as Virginia.

Total damage in the Mississippi-Louisiana-Alabama-Florida area was estimated $20,664,500, of which $11,754,000 was to crops. Damage in Georgia, the Carolinas, Virginia and other eastern states was minor and probably greatly outweighed by beneficial rains which relieved the drought. Eight lives were lost as a direct or indirect result of this storm, four in Louisiana by drowning and four in Alabama.

Hurricane Greta 30 October–7 November

A weak low pressure area drifted northward about 15 mph from the southern Caribbean across eastern Cuba, the central Bahamas, and into the Atlantic Ocean some 500–600 miles off the Florida east coast and slowly intensified, and by November 1st the lowest pressure had reached 998 mbs. Winds of 30–40 mph were evident over an extensive area surrounding the extremely large center, which was characterized by light winds.

The storm continued to move northward to a position about 550 miles east of Daytona Beach, Florida, where it became blocked by a large high pressure system over the North Atlantic preventing further northward progress. The storm described a loop during the night of the 1st and on the 2nd moved southward then southeastward off the Florida coast.

Originally this low had a cold core which is not favorable for development into an intense tropical storm. However, during the period of the loop and the succeeding 24 to 36 hours, it assumed tropical characteristics by becoming a warm core, developed a tight small eye, and had deepened to about 986 mbs. She turned to an easterly course off the central Bahamas, then northeast off Puerto Rico, and on into the central Atlantic.

Greta probably reached hurricane intensity during the afternoon of the 3rd and continued to intensify until the 5th when winds of 120–135 mph and a minimum pressure of 970 mbs were reported by reconnaissance aircraft some 600–700 miles northeast of Puerto Rico. On the 6th and 7th it continued to move rapidly northeast and gradually assumed extratropical characteristics as it passed over much colder water bringing an influx of cold air into its system.

This hurricane touched no land areas after becoming an intense storm; however, the combination of the large high pressure area to the north and the storm caused strong northeast winds on the southeast coast and considerable damage to beaches, particularly in the Jacksonville, Florida, area, and lesser damage elsewhere. Total damage to beaches on the Florida east coast was estimated at more than $1.5 million. Damages to shore installations in Puerto Rico and the Virgin Islands from the high seas and swells were in excess of $2 million.

This was a most unusual storm: first, because of the long period in which it had all the characteristics of a cold low, and second, the rapid intensification and the formation of a tight knit eye or center as it moved southeast and east. It is not known what caused the rapid intensification. Data collected by aircraft attached to the National Hurricane Research Project of the Weather Bureau may prove to be valuable in arriving at the final solution.

The 1956 hurricane season was characterized by about the normal number of easterly waves and tropical depressions. Sea surface temperatures of near to slightly below normal prevailed over portions of the area of tropical storm genesis for part of the season. Temperatures of 81° F or higher are normally accepted as essential for hurricane formation. Other criteria essential for storm development, such as a deep easterly circulation, and a barotropic atmosphere, are associated more with the general circulation. Early this summer the subtropical high pressure ridge over the Atlantic, which extends westward into the southeast United States, was displaced southward of its normal position and averaged about normal strength, a distribution which allowed the westerlies to penetrate considerably farther south than under normal conditions. To a great extent this limited the area of hurricane formation and also deflected incipient storms in the Atlantic away from the east coast of the United States.

Circulation (*Continued from page 13*)

produced a simple temperature type: namely above normal temperatures in the western half of the country and below normal in the East. San Diego, California, had the highest average maximum temperature for any month of record, whereas Albany, N. Y., had its coldest September in 120 years. The precipitation pattern was also straightforward, with excessive rainfall from the Appalachians eastward and subnormal amounts in practically all other parts of the nation. This further aggravated the severe drought in the central and southern Plains States.

The large scale circulation became more favorable for hurricane activity in September, as blocking relaxed and the westerly jet stream moved northward to its normal latitude for the month. In all, four tropical cyclones were identified in the Atlantic, Caribbean, and Gulf of Mexico. This was greater than the usual September frequency. Only one of these, hurricane Flossy, entered the United States, where it caused heavy rain and considerable damage in the Southeast.

The mean 700 mb map for the month of October 1956 is portrayed in figure 7. Its most prominent feature is a strong ridge in the central Pacific, in the very region where a deeper than normal trough had been located during September. Heights in this ridge were 500 ft above normal, the greatest positive anomaly of record for any part of the Northern Hemisphere in October. In the United States the upper-level circulation was again simple in nature, but it was nearly opposite in phase to the pattern which had prevailed during September. This time a deep mean trough was located along the West Coast, with a strong mean ridge in the East. Consequently temperatures averaged below normal west of the Continental Divide but above normal in the remainder of the nation. In much of the country anomalous flow components at 700 mb were from the south during October, whereas they had been northerly in September. As a result precipitation was more widespread and copious in October, and some drought relief was effected in many critical areas.

In November an oscillation of the mean 700 mb heights occurred, and the circulation tended to return to the pattern of September. A stronger than normal ridge now appeared along the west coast of the United States, while cyclonic flow around a mean trough dominated the eastern half of the nation. This circulation was accompanied by light precipitation in the country as a whole, as the West, South, and Southeast received subnormal amounts, and only the northern Plains and a small area around Arkansas received much more than the monthly average. Anomalous flow components from the north were responsible for cool, as well as dry, weather in most of the nation. Largest changes in temperature occurred in the southern Plains, where the much above normal temperatures of October were replaced by much below normal in November. In some areas, however, anomalies persisted from October despite the change in circulation pattern. For example, in the northern tier of states east of the Rockies, temperatures continued above normal because of abnormally warm air and fast westerly flow of the high index type in the Canadian source region. A more striking example is the Great Basin which had below normal temperatures in October because of an influx of cool maritime air under cyclonic flow aloft, and remained below normal in November under anticyclonic conditions which enhanced radiational cooling. South of this Basin High, easterly circulation produced foehn winds whose warm dry properties created an acute forest fire hazard in Southern California.

One of the more interesting aspects of 1956 was the persistence of below normal temperatures in Alaska. In parts of this Territory the weather has been colder than normal during each of the past 12 months and, in a few areas, for as long as two years. Some indication of this condition is given by the thickness chart for May, figure 4. This cold has generally been accompanied by northerly anomalous flow and below normal heights at 700 mb, as portrayed in figure 2 for January and figure 7 for October. The cold was particularly pronounced during November 1956, when temperatures averaged as much as 15° F below normal for the month.

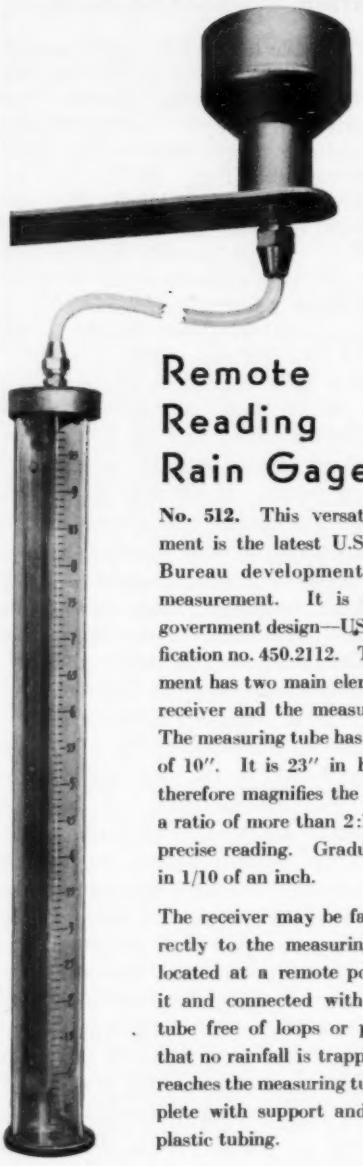
Tornado (*Continued from page 17*)

As previously mentioned, it is notable that with an increasing number of tornado occurrences each year, the loss of life during the past three years, the period of increased interest in the forecasts and warnings, has been quite low. There are several reasons: the very important factor of chance of tornado development relative to populated areas; more experience and emphasis on tornado forecasting; increased public interest following the disasters of 1953; and educational programs aimed at teaching preventative measures to everyone.

Perhaps the most important single factor in the improvement of local and short-range warnings has been the utilization of radar. Contrary to popular belief, radar does not "see" a tornado. True, there have been a few instances where "hooks" and varied-shaped radar echoes have been associated with tornado occurrences. However, at present not enough is known to formulate definite rules as to the appearance of a tornado on the radar scope, except in occasional instances. One of these occurred at College Station, Texas, on 5 April 1956 when a particular echo shape was considered by the radar meteorologist to be of sufficient significance to justify a local warning. The warning was generally believed to have saved a number of lives as the tornado moved through Bryan and College Station. But the most important current use of radar is in detecting strong echoes (strong convective cells with hail or heavy rain); rapid development; development to unusual heights; areas of marked convergence of echo paths; and well-defined lines of strong convective echoes. As observers and radar meteorologists gain more experience in this field, augmented by radar research, it is expected that radar will play an increasingly important role in local short-range warnings and, thus, in saving lives.

REFERENCES

1. Finley, J. P., 1888: "Tornadoes, What They Are." J. H. Soule, p. 43.
2. U. S. Weather Bureau, 1952: "Tornado Occurrences in the United States." U. S. Weather Bureau Technical Paper No. 20.



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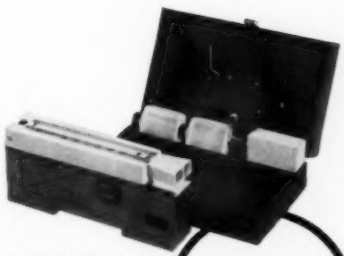

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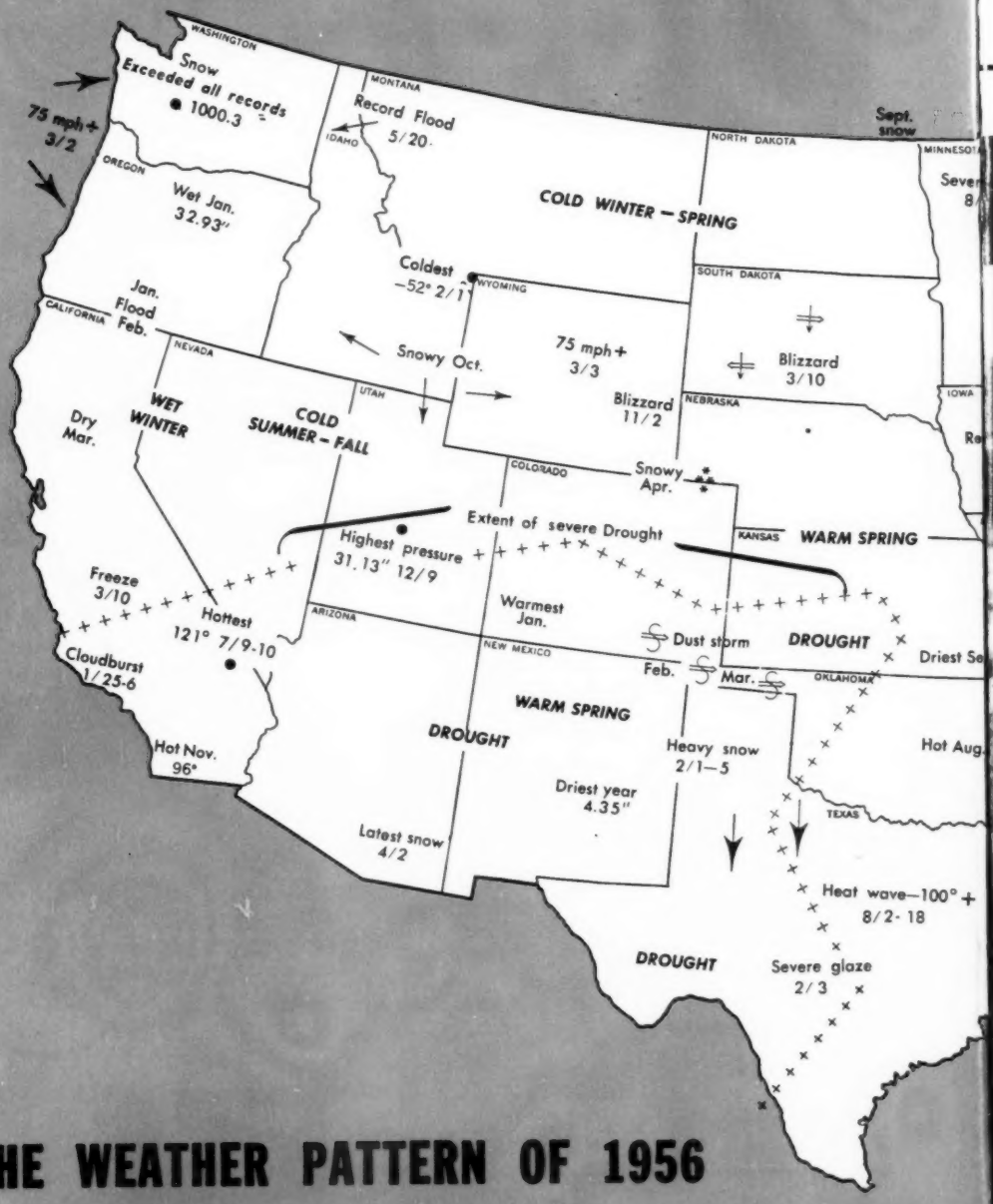

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